En Route Descent Advisor (EDA) Build 3 System Specification

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1.0 Scope

The specifications of this document define the initial En Route Descent Advisor (EDA) System/Subsystem requirements for Build 3. EDA is the NASA Decision Support Tool (DST) for supporting sector controllers in the efficient handling of en route traffic. The specifications of this document were derived from AATT milestone 5.10 report (EDA Concept Definition), the TO 34B final report, The 1997 CSC Descent Advisor Functional Description, Task Order 45 Statement of Work and interactions (mainly through emails and follow-up telephone conversations) with the customer.

These specifications define EDA to a level of detail from which a software design can be created. Also, this document is an evolving work, and as EDA sub-functions are designed, the content of this document will grow and change, as necessary.

1.1 Identification

NASA will use EDA to explore en route concepts for the sector controller. EDA must support the anticipated research of the ground system components of DAG-TM CE 5 (En Route Free Maneuvering) and CE 6 (En Route Trajectory Negotiation), including the EDA DST and En route (air-ground) Data Exchange (EDX) enhancements for integrating EDA with the FMS.

1.2 System Overview

In order to accomplish the goal of supporting NASA en route concepts, EDA must support the following high-level functions. This document describes these functions in detail in subsequent sections.

- Trajectory-Oriented Planning and Conformance Monitoring
- Flow Rate Conformance
  - Metering
  - En Route Spacing
- Separation Assurance
  - Conflict Detection
  - Conflict Resolution
- User Trajectory Negotiation
- Trajectory Generation
- Intent Inferencing

1.3 Document Overview

This document is divided into several sections. The current section, 1.0, overviews the EDA concept and the document. Section 2.0 provides document references, Section 3.0 details the requirements for EDA, Section 4.0 supplies qualification provisions, and Section 5.0 traces the requirements to their sources. Any miscellaneous notes are contained in Section 6.0, and other relevant information is in the Appendices at the end of this document.

2.0 Referenced Documents

[1] Green, S; Vivona, R: “En-route Descent Advisor (EDA) Concept,” AATT Milestone 5.10, NASA Ames, September 30, 1999.

[2] Vivona, R: “Active vs. Provisional Planning in EDA,” AATT NRA Task Order 45 White Paper, Titan Systems Corporation, October 11, 2000.

[3] Vivona, R; et al: “A System Concept for Facilitating User Preferences in En Route Airspace,” NASA Technical Memorandum 4763, November 1996.

[4] Slattery, R; Green, S: “Conflict-Free Trajectory Planning for Air Traffic Control Automation,” NASA Technical Memorandum 108790, January 1994.

[5] den Braven, W,: “Design and Evaluation of an Advanced Air-Ground Data-Link System for Air Traffic Control,” NASA Technical Memorandum 103899, January 1992.

[6] “CTAS ‘C’ Coding Conventions, Standard (ANSI) C Version 3.3,” Aviation Operations Systems Development Branch, NASA Ames Research Center, Moffett Field, CA, April 10, 1998.

[7] “Center TRACON Automation System, The C++ Coding Standard Release 1.1,” Air Traffic Management Branch, NASA Ames Research Center, Moffett Field, CA, June 20, 1997.

[8] “Center TRACON Automation System, The Java Coding Standard Release 1.0,” Aviation Operations Systems Development Branch, NASA Ames Research Center, Moffett Field, CA, November 18, 1999.

3.0 Requirements

3.1 Required States and Modes

EDA requires only a single mode for operation and does not have distinct requirements for additional states or modes.

3.2 System Capability Requirements

This section lists the requirements for each capability of EDA. Traceability of these requirements to EDA related concept documents is provided in Section 5.0 Requirements Traceability.

3.2.1 Trajectory-Oriented Planning and Conformance Monitoring

Trajectory-oriented planning and conformance monitoring are supported by the definition of an active plan trajectory and a provisional plan trajectory for each aircraft. The definition and development of these trajectories are described in the next two sections. Since these two types of trajectories are the foundation upon which all other EDA capabilities are based, the use of these trajectories will be further clarified in the descriptions of the other EDA capabilities. For more information on active and provisional plan trajectories, see references [1] and [2].

To define the active and provisional plan trajectories for an aircraft, we must first define the concept of “ownership.” The sector that owns an aircraft is the sector that is controlling that aircraft. The current CTAS definition of sector ownership is sufficient for EDA. During a handoff between sectors, the transfer of ownership occurs when the receiving sector accepts the handoff.

3.2.1.1 Active Plan Trajectory

The active plan trajectory represents the best prediction of the aircraft’s trajectory given current clearances and any expected transitions. Each aircraft has one and only one active plan trajectory. This trajectory is “visible” to all sectors, regardless of ownership. This means that changes to the active plan trajectory can cause impacts (e.g., create conflicts) with owned and un-owned aircraft that are potentially visible to all sector controllers. Though the active plan trajectory is visible to multiple sectors, only the sector that owns the aircraft can make modifications to the active plan trajectory. This is equivalent to the owning controller having read and write access and non-owning sectors having read-only access to the active plan trajectory.

The logic for building the active trajectory depends upon the combination of clearances, constraints, and controller/pilot intent for the aircraft. The current algorithms for developing an aircraft's non-trial plan trajectory within the baseline CTAS system are sufficient[1] for an aircraft that does not have any active inputs (see below). The logic for developing the active plan trajectory will be modified, as necessary, to support future EDA functionality.

A controller must be able to update the active plan trajectory by making "active inputs" into EDA. Table 3.2.1-1 shows a list of the active inputs that EDA must accept.

Table 3.2.1-1 EDA active inputs

Input	Description
Flight Plan Modifications	Change the active flight plan to the input route (baseline CTAS flight plan amendment acceptable)
Direct-to route modifications	Initiate an immediate turn to the input fix, continue along flight plan route (TBD)
Ignore crossing restriction	Remove the next crossing restriction from the aircraft's active plan (TBD)
Modify crossing restriction	Change the altitude and speed of the next crossing restriction in the aircraft's active plan (baseline CTAS capability acceptable)
Immediate climb/descent to altitude	Begin an immediate climb/descent to the entered altitude (baseline CTAS new cruise altitude command acceptable)
Holding	Initiate air holding pattern at next published location (TBD)
Release from holding	Initiate a turn towards the inside of the pattern, re-establish on the in-bound leg, continue inbound on flight plan (TBD)
Change in airway	Update flight plan route (baseline CTAS flight plan amendment acceptable)
Climb/descend at a fix (defined TOD)	Initiate a climb/descent at the input fix. If before a crossing restriction, use fix as controller defined TOD (TBD)
Immediate increase/reduce (cruise) speed	Begin an immediate acceleration/deceleration to the input speed (baseline CTAS cruise speed change command acceptable)
S turn	Initiate flow conformance advisory of same name in active plan trajectory (TBD)
Path stretch	Initiate flow conformance advisory of same name in active plan trajectory (baseline CTAS capability, including auxiliary waypoints, acceptable)

[1] An option to allow flow conformance advisory generation within the active plan trajectory is desired. The current EDA Build 3 does not currently define this behavior. Advisory generation within the active plan trajectory should perform exactly as for provisional plan trajectories, as described in Section 3.2.2.

Descent Speed	Use entered descent speed (Mach/IAS or just IAS) in transition to metering fix (baseline CTAS descent speed command acceptable)

Active inputs can be created either by direct controller input or through controller acceptance (e.g., activation) of a provisional input (see Section 3.2.1.2).

3.2.1.2 Provisional Plan Trajectory

Provisional plan trajectories are developed within EDA to allow the controller to evaluate the impact of changing the active plan for an aircraft. The provisional plan trajectory represents what the active plan trajectory would look like after all of the provisional elements for that aircraft are accepted. Provisional plan elements include provisional inputs (directly input by the controller) and EDA generated advisory clearances (e.g., resolution and flow conformance maneuvers).

A provisional plan trajectory is generated upon receipt of the first provisional element for that aircraft. The provisional plan trajectory is generated by modifying the active plan trajectory in accordance with the provisional element. Provisional elements can either add to the active plan trajectory (e.g., a provisional change in cruise altitude) or can modify an existing element of the active plan (e.g., changing a future descent speed from the company desired speed to an input descent speed). More than one provisional element can exist in a provisional plan, including combinations of provisional inputs and generated advisories. As each additional provisional element is generated/entered, it either adds to or modifies the active plan. Each provisional element should be able to be removed independently of all other provisional elements. The last change to provisional elements (including the addition and subtraction of inputs) should also be able to be quickly removed, allowing the controller to return to previous provisional plan trajectories, similar to the “undo” feature in word processing software.

Provisional elements can be “accepted” by making them active. Accepting a provisional element modifies the active plan trajectory for that aircraft by adding the provisional element or replacing an existing active plan element with the provisional element. The provisional element is then removed from the provisional plan trajectory (the information is now a part of the active plan, so a provisional element is no longer needed). Only the sector that owns the aircraft can accept provisional elements and make them active. Other sectors can create provisional plans to support internal planning, but they cannot activate the provisional elements. A quick method for accepting all provisional planning elements should be available.

Only one provisional plan trajectory exists for each aircraft for a given controller. Two or more controllers can have different provisional plan trajectories for the same aircraft. A provisional plan trajectory is, by default, visible (read and write access) only to the controller who created it. The creator of a provisional plan trajectory (not necessarily the owner of the aircraft) can “share” a provisional plan trajectory with another controller. Sharing enables another controller to have read-only access to the provisional plan trajectory until sharing is turned off.

If a controller wants to make changes to a shared trajectory, EDA must allow them to make a copy of the current shared provisional plan trajectory. Any modifications made to this copy are not reflected in the sharing controller’s provisional plan trajectory. Since the new controller does not own the aircraft (only the owner of the aircraft can share the original provisional plan trajectory), changes made to this copy of the shared trajectory cannot be made active.

To support trajectory negotiation between an aircraft and a controller, EDA must support a provisional plan trajectory being sent from an aircraft to a controller. The current idea is that an aircraft will datalink down a provisional plan trajectory for evaluation and negotiation. In this case, if the controller already has a provisional plan trajectory for that aircraft, a copy of the aircraft's provisional plan trajectory replaces (after the controller accepts the receipt of the provisional plan) the controller's current provisional plan trajectory. The controller can use the "undo" feature if they want to return to their previous provisional plan trajectory. Since it is a copy of the aircraft's provisional plan trajectory, the controller can make modifications to the provisional plan trajectory. The final provisional plan trajectory can be sent back to the aircraft. After negotiation, the controller can make the entire provisional plan active and issue clearances to the aircraft.

All active inputs (Table 3.2.1-1) should be available as provisional inputs. Additional inputs that impact the generation of the provisional plan trajectory, specifically those associated with flow conformance and separation assurance advisories, are discussed in the sections describing those functionalities.

3.2.1.3 Active Plan Monitoring

EDA shall support the monitoring of an aircraft's conformance to the active plan trajectory.[2] The elements of the active plan that shall be checked for conformance are included in Table 3.2.1-2. Non-conformance will be indicated to the controller.

Table 3.2.1-2: Active Plan Elements for Conformance Checking

Altitude	Cruise, cleared, crossing restrictions
Speed	Cruise, descent, climb
Route	Lateral path
Time	See flow conformance

3.2.1.4 Provisional Plan Monitoring

EDA shall support the monitoring of flow conformance and separation assurance for an aircraft's provisional plan. Monitoring other elements for conformance to the provisional plan trajectory is not required.

3.2.1.5 Requirement Statements

Number	Requirement Statement
TP-1	EDA shall support the development of active and provisional plans
TP-2	EDA shall support distributed air-ground (user-ATM) trajectory planning
TP-3	EDA shall support airborne free maneuvering
TP-4	EDA planning shall support intra-sector (R- and D-side) coordination of trajectory plans
TP-5	EDA planning shall support inter-sector (two or more sectors within a facility) of trajectory plans

[2] If flow conformance advisories are added to the active plan trajectory (see Footnote in Section 3.2.1.1), these advisories should not be checked for conformance, since the aircraft has not been issued clearances based on these advisories.

TP-6	EDA planning shall support inter-facility (two or more sectors in two or more facilities) of trajectory plans
TP-7	EDA shall support controller input trial plans
TP-8	EDA trial planning shall integrate with flow conformance capabilities to provide flow conformance feedback during trial planning
TP-9	EDA planning shall provide direct and continuous feedback on each flight's conformance with the active clearance (controller intent)
TP-10	EDA shall accept manual controller inputs to update the active plan
TP-11	EDA shall support a common situational awareness across sectors to ensure complementary plans and actions
TP-12	EDA shall support controller input of all commonly used actions to change the nominal flight plan, including: direct-to route modifications; path-stretch/S turns; air hold; release air hold; change in airway; ignore crossing restriction; modify crossing restriction; immediate climb/descent; climb/descend at a fix; immediate increase/reduce speed
TP-13	EDA shall calculate each clearance's (route, altitude, speed) conformance and indicate non-conformant states
TP-14	EDA shall support the controller situation awareness of the active plan, advisory mode and controller constraints/overrides, pending decision points and required actions, and conformance to active plan
TP-15	EDA trajectory-oriented planning shall be configurable by controllers
TP-16	EDA shall support the Upstream Sector Team concept for inter-sector coordination
TP-17	EDA shall take downstream conflicts, merges and flow constraints into account during planning
TP-18	EDA shall develop controller plans based on accurate intent
TP-19	EDA shall use "active" inputs (speed, altitude, routing) to improve controller intent in trajectory predictions
TP-20	EDA shall create R-side functionality with supporting D-side functionality
TP-21	EDA shall provide maneuver feedback that allows a controller to observe the progressive effect of a clearance issued but not input into the system
TP-22	EDA shall support inter-sector coordination through the electronic exchange of provisional plans
TP-23	EDA shall support non-verbal inter-sector coordination through coordinated information display
TP-24	EDA shall provide integrated non-standard route planning, clearance advisory and monitoring (including free vectoring)

3.2.2 Flow Rate Conformance

Two types of Flow Rate Conformance exist within EDA: metering and spacing.

3.2.2.1 Metering

Each aircraft within EDA may have only one metering restriction imposed on it at a time. However, within EDA, multiple metering flow restrictions may exist simultaneously, even within one sector.

EDA receives a metering list from the Traffic Management Advisor (TMA). The metering list consists of Scheduled Times of Arrival (STA) for aircraft being metered to defined metering fixes. Based on this metering list, EDA identifies each aircraft that has a metering constraint and monitors their conformance to the constraint. The constraint consists of an STA for that aircraft to a metering fix. The EDA metering capability performs two primary functions for each aircraft with a metering constraint: performs a flow conformance check and (if in an advisory generation mode) produces advisories to achieve flow conformance.

<u>3.2.2.1.1 Metering (Flow) Conformance</u>

All aircraft with a metering constraint are checked for flow conformance. To assess an aircraft's conformance to a metering constraint, EDA uses the aircraft's active plan trajectory (see Section 3.2.1.1). If the prediction arrives at the metering fix (i.e., the aircraft's Estimated Time of Arrival (ETA) at the metering fix) within a parameter number of seconds[3] of the STA, then the metering constraint is met. These flow conformance checks are characterized by a delay value, which is the time by which an aircraft misses its conformance to its restriction (i.e., delay = STA – ETA). This delay value is displayed to the controller for conformance feedback in the sector's metering list.

<u>3.2.2.1.2 Metering Advisories</u>

If an aircraft's active plan trajectory is not in conformance with its STA, EDA provides two advisory generation modes for generating a provisional plan trajectory[4] to meet the STA: Automatic and Semi-Automatic. In Automatic mode, EDA identifies each aircraft that does not meet its required STA and automatically generates a provisional plan trajectory to meet the STA. In Semi-Automatic mode, advisory generation is not initiated unless a controller selects an aircraft for advisory generation. Whether in automatic or semi-automatic mode, once advisory generation is initiated, degrees of freedom (DOF) are selected (see next) and a provisional plan trajectory to meet the time is generated.

EDA provides three DOF selection modes for flow conformance: Manual, Controller-Defined, and EDA-Defined. These modes are described in Section 3.2.2.3.1. In Manual mode, no DOFs are selected and EDA provides conformance checking only. Based on the aircraft's required delay, the controller enters active or provisional inputs to modify the aircraft's ETA until the STA is met. In Controller-Defined or EDA-Defined mode, a provisional plan trajectory is developed that meets, to the degree allowable by the selected DOF(s), the STA. Any residual delay that is not absorbed by the provisional plan trajectory is displayed to the controller within the sequence list. Each sector must be able to define its own metering modes (advisory generation and DOF selection), independent of all other sectors.

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[3] The current parameter used within the baseline TS is acceptable.

[4] EDA Build 3 currently assumes that flow conformance advisory generation is added as provisional elements to create or modify an existing provisional plan trajectory. The ability to add flow conformance advisories to active plan trajectories is an option that also needs to be added. The rest of the discussion for flow conformance remains unchanged with this addition.

During the development of provisional plan trajectories for metering, all other provisional inputs are accommodated. If a provisional input conflicts with the DOF selection mode (e.g., a provisional input exists for one of the DOFs available within the DOF selection mode), then the provisional input takes precedence. If all available DOFs within the DOF selection mode are over-ridden by provisional inputs, the aircraft trajectory is said to be “over-constrained” and metering advisories are not generated.

After a provisional plan trajectory is developed, this trajectory is probed for conflicts (see Section 3.2.4.1). If a conflict is detected, then the conflict resolution capability of EDA (see Section 3.2.4.2) will determine whether to modify the flow conformant trajectory to meet the time and be conflict free. In this situation, the metering capability of EDA accepts additional provisional input constraints (e.g., representing the value for a resolution degree of freedom), changes to a new externally defined (by conflict resolution) metering DOF selection mode for that aircraft, and calculates new provisional plan trajectories to meet the time. For more information on the integration of flow conformance and conflict resolution, see Section 3.2.4.2.

Based on the final provisional plan trajectory, the advisories generated to meet the STA are displayed to the controller for evaluation and possible manual modification. The controller can manually modify the metering advisory by either changing the DOF selection mode for that aircraft or by entering active or provisional inputs. EDA shall update the metering (and resolution advisories) when changes are received.

EDA shall also provide an advisory “locking” capability that allows the controller to freeze the value of a DOF within advisory generation. Locking an element of the advisory changes it from an EDA calculated value to a provisional input (whose value is equal to the last EDA calculated value for that DOF). A locked advisory DOF can be either “unlocked” (i.e., returned to a an EDA calculated DOF) or over-ridden by a manual (active or provisional) input by the controller.

EDA will provide automatically generated sequence change advisories, but this functionality is currently TBD.

3.2.2.1.3 Requirement Statements

Number	Requirement Statement
MT-1	EDA shall assist controllers in the metering of traffic
MT-2	EDA shall incorporate user preferences into metering
MT-3	EDA shall support the controller in planning and implementing fuel-efficient clearances for conformance to metering constraints
MT-4	EDA will provide active flow-rate conformance advisories for metering
MT-5	EDA metering clearances shall be integrated with CD&R (separation assurance)
MT-6	EDA shall assist the controller with the planning of delay maneuvers for metering
MT-7	EDA shall assist the controller in selecting the most efficient delay absorption techniques
MT-8	EDA shall provide “active” meet-time advisories for fuel-efficient conformance to metering constraints

MT-9	EDA shall detect flow-rate conformance problems up to 20 minutes in the future (1-2 sectors)
MT-10	EDA shall integrate metering conformance advisories with conflict detection and resolution
MT-11	EDA shall provide planning, monitoring, and conformance tracking of metering constraints
MT-12	EDA shall provide "strategically-accurate" flow rate conformance advisories: advising a plan that is nominally in conformance rather than dividing up the responsibility over space and time
MT-13	EDA shall allow the controller to manually adjust automatic resolution advisories
MT-14	EDA shall support the meeting of scheduled times of arrival at the metering fix
MT-15	EDS advisories shall meet scheduled times of arrival within approximately plus/minus 10 seconds
MT-16	EDA shall maximize the use of speed envelopes for maintaining scheduled times of arrival
MT-17	Metering conformance detection and resolution shall be fully configurable by controllers so that preferences can be set and saved.
MT-18	Metering preferences shall include time horizon for conformance problem detection (5-20 min) and resolution (5-20 min)
MT-19	Advisories are determined by iterating on degrees of freedom (DOF) to meet metering constraints
MT-20	Advisories are compliant with crossing restrictions and similar to those generated for advanced onboard Flight Management Systems (FMS)
MT-21	EDA flow conformance functionality shall be configurable by controllers
MT-22	EDA shall maximize FMS utilization
MT-23	EDA shall allow the controller to swap the sequence of two aircraft in the metering list or enter up to 5 aircraft in a preferred sequence for TMA
MT-24	EDA shall generate automatic sequence constraints for TMA

3.2.2.2 En Route Spacing

TBD.

3.2.2.2.1 Requirement Statements

Number	Requirement Statement

ES-1	EDA shall support the controller in planning and implementing fuel-efficient clearances for conformance to en route spacing constraints
ES-2	EDA shall provide active flow-rate conformance advisories for en route spacing
ES-3	EDA spacing clearances shall be integrated with CD&R (separation assurance)
ES-4	EDA shall assist the controller with the planning of delay maneuvers for spacing
ES-5	EDA shall assist the controller in selecting the most efficient delay absorption techniques
ES-6	EDA shall provide “active” meet-time (-spacing) advisories for fuel-efficient conformance to spacing constraints
ES-7	EDA shall detect flow-rate conformance problems up to 20 minutes in the future (1-2 sectors)
ES-8	EDA shall integrate spacing conformance advisories with conflict detection and resolution
ES-9	EDA shall provide planning, monitoring, and conformance tracking of spacing constraints
ES-10	EDA shall provide “strategically-accurate” flow rate conformance advisories: advising a plan that is nominally in conformance rather than dividing up the responsibility over space and time
ES-11	Spacing conformance detection and resolution shall be fully configurable by controllers so that preferences can be set and saved.
ES-12	Spacing preferences shall include time horizon for conformance problem detection (5-20 min) and resolution (5-20 min)
ES-13	Advisories are determined by iterating on degrees of freedom (DOF) to meet spacing constraints
ES-14	Advisories are compliant with crossing restrictions and similar to those generated for advanced onboard Flight Management Systems (FMS)
ES-15	EDA shall provide the controller with an estimation of separation between aircraft arriving at a future merge point
ES-16	EDA flow conformance functionality shall be configurable by controllers
ES-17	EDA shall allow the definition of an arbitrary location in space to be used as reference for spacing calculations
ES-18	EDA shall support multiple streams of traffic for spacing based on unique reference fixes and/or altitudes
ES-19	EDA shall automatically identify information for streams of traffic (ID aircraft, ID reference fix, etc.) given general information from the controllers

ES-20	EDA shall support the coordination of spacing streams among sector controller teams
ES-21	EDA shall maximize FMS utilization
ES-22	EDA shall provide mile-in-trail constraint spacing feedback
ES-23	EDA shall provide spacing advisories shall support en route and metering fix constraints for aircraft on different flight paths
ES-24	EDA shall provide multi-aircraft minimum separation feedback to identify dynamic "choke points" for streams of aircraft on non-standard routes

3.2.2.3 Active Advisory Generation for Flow Conformance

3.2.2.3.1 Flow Conformance DOF Selection Modes

EDA shall support three DOF selection modes for flow conformance (both metering and spacing) advisory generation:

1. Manual
2. Controller-defined
3. EDA-defined

Manual Flow Conformance DOF Selection Mode

In manual mode, no DOFs are selected for advisory generation. EDA shall not generate a flow conformance advisory, but shall provide flow conformance checking (e.g., metering delay) only.

Controller-Defined Flow Conformance DOF Selection Mode

In controller-defined mode, the controller shall select the combination of DOFs that shall be applied to an aircraft (in standard modes that also define, if the mode contains more than one DOF, the order in which the DOFs are applied) for flow conformance advisory generation. A controller-defined DOF selection mode is either applied to an aircraft through a general setup parameter within EDA (e.g., a setup panel that sets all arrival aircraft to default to "Descent Only" speed mode[5]) or through a controller input for that aircraft (e.g., switching a specific arrival aircraft from the default mode to a different flow conformance mode). Each aircraft within EDA must be able to have a unique flow conformance mode.

There are three types of controller-defined flow conformance DOF selection modes for EDA: speed only; speed with altitude; and lateral path. Only one mode within one of the three types can be selected for any one aircraft at any one time.

EDA has five speed-only modes: Descent only; Cruise only; Cruise and Descent; Cruise then Descent; and Cruise equals Descent. These speed modes should follow the algorithms within the baseline (C version of TS) CTAS system.

[5] It is anticipated that setup panels may be desired which defaults flow conformance DOF selection modes for groups of aircraft to specific modes. For example, all metered jet aircraft may default to "Cruise Equals Descent" speed mode where jets under en route spacing restrictions should default to "Lateral Path" mode. This functionality is TBD.

EDA has one speed with altitude mode: slowest descent cruise. This mode should follow the algorithm within the baseline (C version of TS) CTAS system.

EDA has two lateral path modes: Path Stretch and S-Turn. The Path Stretch mode should follow the algorithm within the baseline (C version of TS) CTAS system, with the addition of the capability to send an aircraft on a direct path to the metering fix for negative delay absorption. The algorithm for the S-Turn mode is TBD.

EDA -Defined Flow Conformance DOF Selection Mode

In the EDA-defined flow conformance DOF selection mode, the controller elects to have algorithms within EDA choose an appropriate DOF(s) to meet the flow conformance restriction. In this mode, the controller shall be able to restrict certain DOFs from being selected by EDA, allowing EDA to choose from all remaining available DOFs.

The possible DOFs that should be available to EDA (and available for restriction by the controller) are:

1. Speed – including descent and cruise
2. Altitude
3. Lateral Path – including path stretch and s-turn

3.2.2.3.2 Requirement Statements

Number	Requirement Statement
AG-1	EDA shall provide cruise and descent speed advisories
AG-2	EDA shall provide three speed profile advisory modes: Cruise-only; Descent-only; and Cruise-Plus-Descent
AG-3	Cruise-only mode shall iterate within the aircraft's cruise speed envelope to determine a new cruise speed to meet the flow conformance constraint
AG-4	Descent-only mode shall iterate within the aircraft's descent speed envelope to determine a descent-speed profile (Mach/KIAS) to meet the flow conformance constraint
AG-5	Cruise-Plus-Descent mode shall iterate on both descent- and cruise-speed profiles to meet the flow conformance constraint
AG-6	EDA shall generate top-of-descent (TOD) advisories and descent profiles as a function of selected speed profile, 3D crossing restriction, aircraft performance; and atmospheric state
AG-7	EDA shall generate new cruise-altitude advisories to meet flow conformance constraints
AG-8	EDA shall generate path-stretch (PS) advisories as its primary lateral-profile advisory for flow rate conformance
AG-9	PS mode shall iterate on the range to fly along a controller defined vector before the flight is returned to its route at a controller defined capture waypoint
AG-10	EDA shall provide a manual version of PS mode called "Delay

	Countdown" (DC) mode
AG-11	DC mode shall provide feedback on the state of each flight, indicating delay remaining to be absorbed
AG-12	EDA shall cue the controller to laterally expedite a flight if flow conformance constraints (i.e., metering delays or spacing) can be reduced
AG-13	EDA shall provide flexible advisory capabilities for flow rate conformance
AG-14	DC mode shall provide identical delay feedback a provided by basic TMA metering (albeit at a much lower level of accuracy)
AG-15	Advisories are calculated for arrival aircraft from their top-of-ascent (TOA) positions to their metering fixes
AG-16	Cruise advisories pertain to the speed (cruise speed advisory) and altitude (new cruise altitude advisory) of the aircraft between TOA and TOD
AG-17	Descent profile advisories pertain to the vertical profile of the aircraft between the TOD and metering fix
AG-18	EDA shall use the company preferred descent profile, unless required to change based on constraints
AG-19	Descent profiles shall minimize powered flight at low altitude and permit idle thrust descents
AG-20	EDA shall provide continuous updates of clearance advisories

3.2.3 Trajectory Generation

Current CTAS Trajectory Generation is considered adequate for Build 3 EDA, except as noted below. As EDA capabilities are further defined, new requirements for trajectory generation will be identified, as necessary.

3.2.3.1 Lateral Path Generation

This section contains a brief description of the key EDA advisory modes for lateral path generation. The two primary functions for lateral path generation are Route Intercept (RI) and Waypoint Capture (WC).

Waypoint Capture

The waypoint capture mode determines the future path based on the aircraft's current state (position and velocity), the flight plan and a controller defined capture waypoint. The WC mode builds a path starting at the aircraft's current position and performs an immediate turn to proceed direct to the capture waypoint, as shown in Figure 3.2.3-1. The remainder of the lateral path follows the aircraft's flight plan route. Selection of the capture waypoint is as in the CTAS baseline. Behavior of WC mode when then capture waypoint is not on the aircraft's flight plan is TBD.

Route Intercept

The route intercept mode determines the future path based on the aircraft's current state and flight plan route. Two methods for route intercept are under consideration. Both algorithms should be available and configurable during EDA setup.

The first method, illustrated in Figure 3.2.3-1, determines the future path by connecting a direct course along the aircraft's current heading to the point of intersection with the flight plan route (shown as the red triangle in Figure 3.2.3-1). The aircraft flies directly to the intersection point and then turns to rejoin the original flight plan.

The second method, also illustrated in Figure 3.2.3-1, determines the future path by finding the next waypoint on the flight plan route that is "in front of" the aircraft. The path starts at the aircraft's current position, performs an immediately turn to proceed direct to this waypoint and rejoins the flight plan at that location. The next waypoint is found by constructing a search cone (as shown in Figure 3.2.3-1) based on the aircraft's current heading[6]. If multiple waypoints are within the search cone, the closest waypoint to the aircraft is chosen.

Handling special cases where no waypoints are within the search cone or the aircraft's heading projection does not intersect the flight plan route are TBD.

S-Turn

EDA must accept an S-turn identified by the EDA interface and add it to the lateral path. Specific definitions of S-turn segments are TBD.

Holding Pattern

EDA must generate a "box" representing airspace to protect when an aircraft is in a holding pattern. The specific definition of this box is TBD.

Auxiliary Waypoint Function

The current CTAS baseline approach for defining and processing auxiliary waypoints is assumed to be adequate for EDA Build 3.

[6] The search cone is constructed by projecting two lines to the right and left of the aircraft's heading. The actual off-set (in degrees) of these lines from the aircraft's heading is TBD.

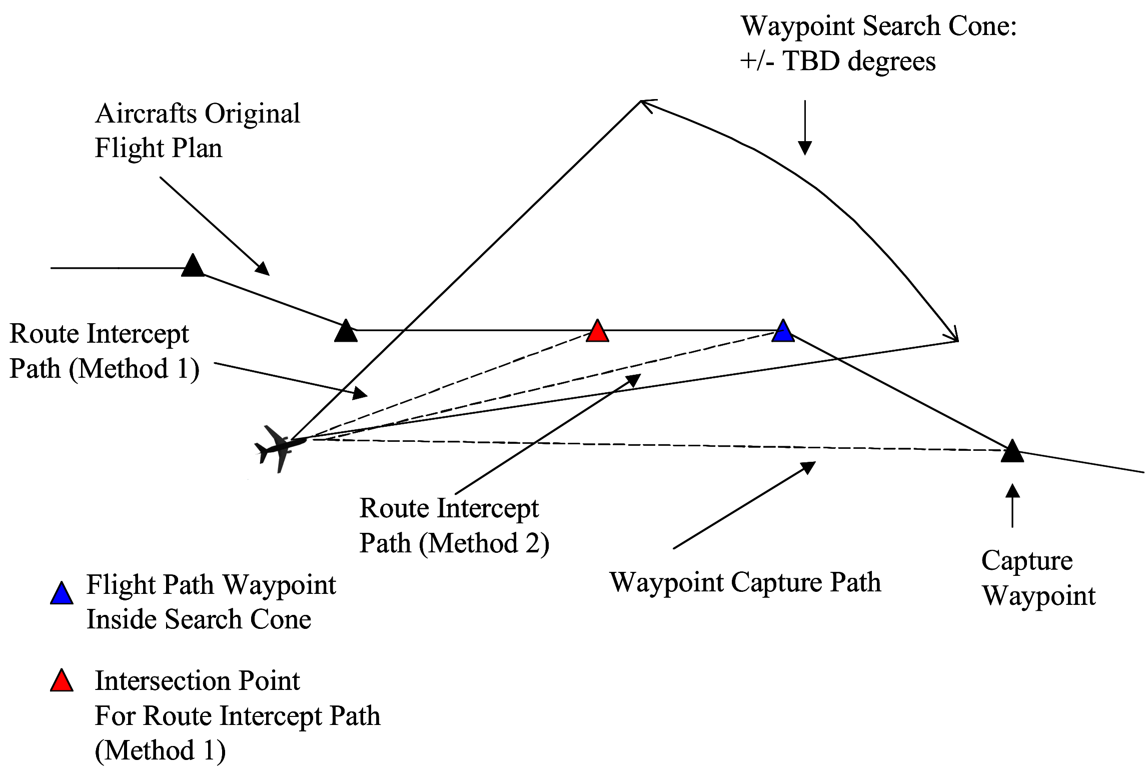

Figure 3.2.3-1. Illustration of basic EDA navigation modes

3.2.3.2 Requirements Statements

Number	Requirement Statement
TG-1	EDA shall provide accurate 4D trajectory predictions
TG-2	EDA shall predict trajectories 20 minutes into the future
TG-3	EDA shall provide “seconds” accuracy in trajectory predictions
TG-4	EDA trajectory prediction shall support the removal of static lateral restrictions prior to the TRACON and at the TRACON boundary
TG-5	EDA trajectory prediction shall integrate point-mass model kinetic equations of motion based on first principals (three translational dimensions plus roll)
TG-6	EDA shall support two primary navigation modes – Route Intercept (RI) and Waypoint Capture (WC)
TG-7	RI mode shall determine future path based on the flight’s current state, flight plan route, and any ATSP-defined route structures (e.g., STARS)
TG-8	WC mode shall determine future path based on the flight’s current state, a controller defined “capture” waypoint, the flight plan route, and any ATSP-defined route structures (e.g., STARS)
TG-9	EDA shall generate S-turns trajectories for a prescribed amount of time

TG-10	EDA shall generate holding patterns by pausing trajectory synthesis prediction until after the aircraft is released from the holding pattern
TG-11	EDA trajectory generation shall use the same approach as that by FMS systems (compatible with airborne LNAV-VNAV)
TG-12	EDA shall account for the thrust and drag characteristics of each aircraft type
TG-13	EDA shall model the effect of speed profile and wind gradient on vertical rate
TG-14	EDA shall model pilot procedures and operator preferences during trajectory prediction
TG-15	EDA shall be able to generate trajectories using time as an independent variable to meet STA restrictions
TG-16	EDA shall provide trajectories with arrival time prediction accuracy [cumulative prediction accuracy over length of trajectory) to 20 seconds or less
TG-17	EDA shall allow the definition of an arbitrary location in space as a waypoint for trajectory generation of later paths [auxiliary waypoint]
TG-18	EDA shall provide continuous updates of trajectory predictions
TG-19	EDA shall support both standard (jet and victor routes, NAVAIDS) and non-standard (NRP routes, free vectors, direct and best-wind routes)

3.2.4 Separation Assurance

3.2.4.1 Conflict Detection

The current CTAS algorithms used to define a loss of separation between aircraft and to probe two trajectories to identify a loss of separation is assumed to be adequate for EDA Build 3. The following discussion assumes these algorithms as a foundation. The number of trajectories that need to be probed is based on the new definition of trajectory and conflicts types and has to be updated in the current CTAS implementation.

Conflict detection must support the detection of potential conflicts between active plan trajectories and provisional plan trajectories. Each aircraft in EDA has at least an active plan trajectory (see Section 3.2.1.1). Each aircraft may also have a provisional plan trajectory (see Section 3.2.1.2) and may have multiple provisional plan trajectories (i.e., more than one controller may have a provisional plan for the same aircraft). The conflict detection capability of EDA must identify each potential conflict and must properly classify the conflict so the controller can understand the impact of the potential conflict.

The ability to identify conflicts between active/provisional plan trajectories and area hazards (such as weather, Special Use Airspace, aircraft in holding patterns, etc.) is TBD.

3.2.4.1.1 Conflict Classification

When probing an aircraft pair for conflicts, there are four classifications of potential conflicts that can be detected:

1. Active Conflict
2. Provisional Conflict
3. Dependency Alert
4. Coordination Alert

Active Conflict – An active conflict is detected whenever the active plan trajectories of two aircraft are predicted to be in conflict. This is always true, independent of whether one or both of the aircraft have provisional plan trajectories. This is also true whether the aircraft are owned by the same sector or by different controllers.

Provisional Conflict – A provisional conflict is detected in one of the following cases:

1. When both aircraft are owned by or shared with the same sector, only one of the aircraft has a provisional plan trajectory and that provisional plan trajectory has a potential conflict with the active plan trajectory of the other aircraft.
2. When both aircraft are owned by or shared with the same sector, both aircraft have a provisional plan trajectory and the two provisional plan trajectories have a potential conflict.
3. When the two aircraft are owned by different sectors, either one or both of the aircraft have unshared provisional plan trajectories and there is a potential conflict between the unshared provisional plan trajectory of one aircraft with the active plan trajectory of the other aircraft.

In case three above, there is the potential for two provisional conflicts to be detected. If aircraft A is owned by sector 1 and aircraft B is owned by sector 2, then a provisional conflict detected between aircraft A's unshared provisional plan trajectory and aircraft B's active plan trajectory is a provisional conflict that is displayed to sector 1 and a provisional conflict detected between aircraft B's unshared provisional plan trajectory and aircraft A's active plan trajectory is a provisional conflict that is displayed to sector 2. Because aircraft A's and B's provisional plan trajectories are not shared, they are not "visible" outside of their sectors and neither are their provisional conflicts. If aircraft A's provisional plan trajectory was shared with sector 2 but aircraft B's provisional plan trajectory was not shared with sector 1, then a conflict between aircraft A's provisional plan trajectory and aircraft B's provisional plan trajectory would be a provisional conflict for sector 2 (type 2 above), but sector 1 would only see a provisional conflict between aircraft A's provisional plan trajectory and aircraft B's active plan trajectory (type 3 above).

Dependency Alert – When two aircraft are owned by the same sector or both are visible to that sector due to sharing and both have a provisional plan trajectory, there are four potential conflicts that can be identified. One is between the two aircraft's active plan trajectories, which is an active conflict. One is between the two aircraft's provisional plan trajectories, which is a provisional conflict (type 2). The other two exist between aircraft A's provisional plan trajectory and aircraft B's active plan trajectory and, similarly, between aircraft B's provisional plan trajectory and aircraft A's active plan trajectory. Potential conflicts between the provisional plan trajectory of an aircraft with the active plan trajectory of an aircraft with a visible provisional plan trajectory is called a dependency alert. Figure 3.2.4-1 shows an example of two aircraft with both provisional plan and active plan trajectories.

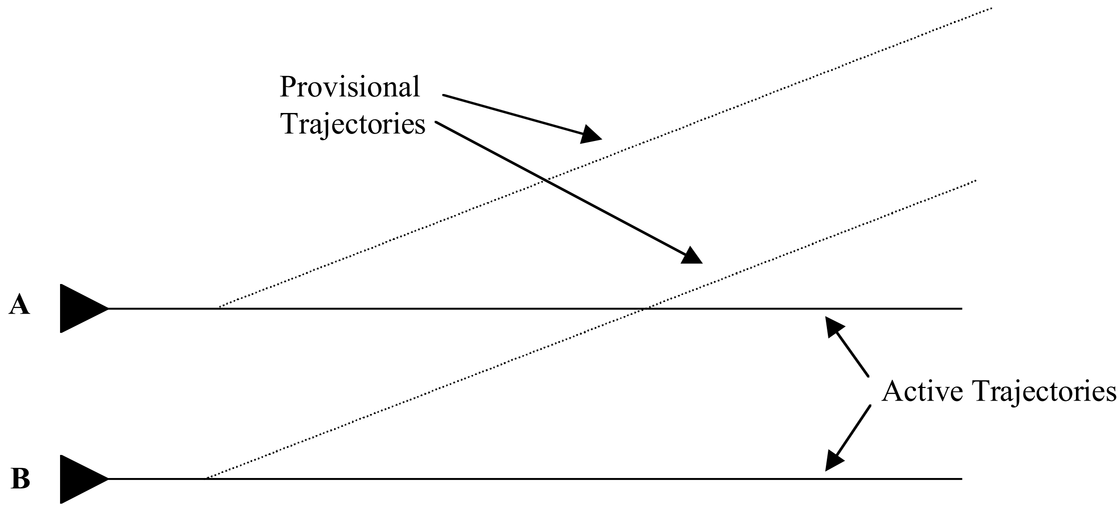

Figure 3.2.4-1: Illustration of dependency conflict classification

In the figure, it is clear that the two active plan trajectories are conflict free (i.e., no active conflicts) as are the two provisional plan trajectories (i.e., no provisional conflicts). What is not clear is that there is a potential conflict between aircraft B's provisional plan trajectory and aircraft A's active plan trajectory. The implication is that if aircraft B's provisional plan trajectory is accepted and made active, that an active conflict will result between aircraft B and aircraft A if aircraft A's provisional plan isn't also made active. This creates a "dependency" for aircraft B's provisional plan trajectory on aircraft A's provisional plan trajectory to avoid an active conflict. Notice that in the example there is not a dependency on aircraft A's provisional plan trajectory, since it can be made active without creating an active conflict independent of whether aircraft B's provisional plan trajectory is made active. Dependency alerts identify a dependency on the aircraft that has the provisional plan trajectory (in the identification of the conflict), not on the other aircraft.

Coordination Alert – When two aircraft are owned by different sectors and both have provisional plan trajectories that are not visible to the other via sharing, there are also four possible conflicts that can be detected. Again, an active conflict is detected between the active plan trajectories. Since neither provisional plan trajectory is shared with the other sector, a provisional conflict (type 3) is detected between aircraft A's provisional plan trajectory and aircraft B's active plan trajectory. This provisional conflict is displayed to aircraft A's owning sector, but not aircraft B's owning sector. Similarly, a provisional conflict (type 3) is detected between aircraft B's provisional plan trajectory and aircraft A's active plan trajectory and is displayed to aircraft B's owning sector but not aircraft A's owning sector. The fourth potential conflict exists between aircraft A's and aircraft B's provisional plan trajectories. Potential conflicts between the provisional plan trajectories of two aircraft that are not owned by the same sector and are not being shared are called coordination alerts. Figure 3.2.4-2 shows an example of two aircraft with both provisional plan and active plan trajectories that are not owned by the same sector and are not sharing their provisional plans with other sectors.

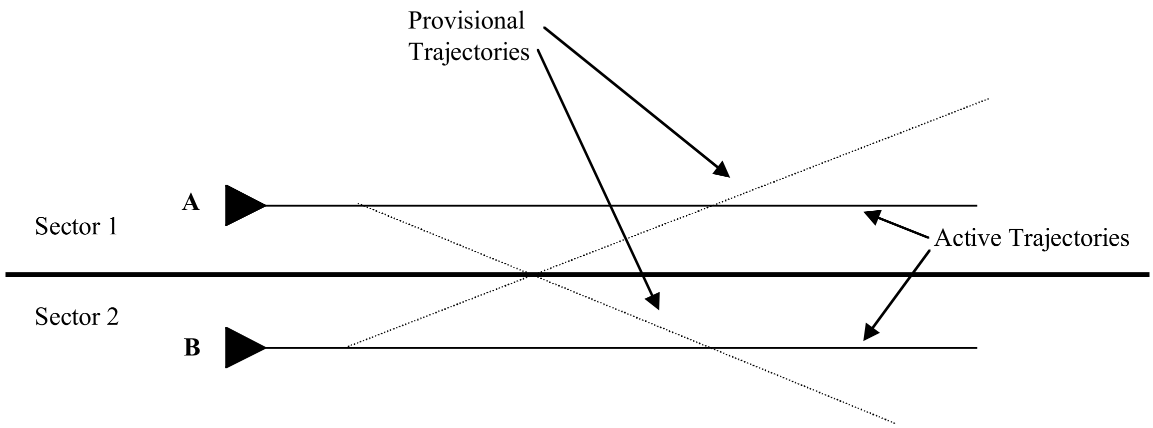

Figure 3.2.4-2: Illustration of warning conflict classification

In the figure, it is clear that the two active plan trajectories are conflict free (i.e., no active conflicts). It is also assumed that aircraft A's provisional plan trajectory is not in conflict with aircraft B's active plan trajectory and aircraft B's provisional plan trajectory is not in conflict with aircraft A's active plan trajectory (i.e., no provisional conflicts). If there is a conflict between aircraft A's and aircraft B's provisional plan trajectories, neither sector controller would be aware of this situation by looking at just active and provisional conflicts. The implication is that if one controller accepts (makes active) their provisional trajectory, it would show up as a provisional conflict for the other sector controller. This would not necessarily be a safety problem, but could mess up the other controller's planning or both controllers' planning if they both accept their provisional plan trajectories at (approximately) the same time and the conflict becomes an active conflict. The display of a coordination alert to both sectors that there is a potential conflict between the plans for their aircraft avoids the negative impacts of this situation by alerting both controllers to the potential impact prior to either accepting their provisional plan trajectory. Displays based on coordination alerts are applied to both aircraft.

3.2.4.1.2 Conflict Types

Each active and provisional conflict can be classified into one of four conflict types:

1. Intra-sector Conflict
2. External Intruder Conflict
3. External Conflict
4. Inter-sector Conflict

Figure 3.2.4-3 (next page) depicts some examples of different conflict geometries that create these conflict types. For more discussion of conflict types, see reference [3].

To support the definition of these types, a conflict (as opposed to either aircraft that creates the conflict) is defined as "owned" by a sector when the loss of first separation between the two aircraft geometrically exists within the boundaries of that sector. The combination of aircraft and conflict ownership define the four conflict types:

Intra-sector Conflict – occurs when the two aircraft and the conflict are all owned by the same sector.

External Intruder Conflict – occurs when one sector owns one aircraft and the conflict and a second sector owns the other aircraft.

External Conflict – occurs when the two aircraft are owned by a sector and the conflict is owned by another sector.

Inter-sector Conflict – occurs when the aircraft are each owned by a different sector and the conflict is owned by a third sector.

Two examples are given for the External Intruder, External and Inter-sector conflicts to demonstrate just a few variations that can result for conflicts detected over a twenty minute time horizon. Figure 3.2.4-3d (example 2 of the External Conflict) demonstrates that the conflict type can change as a function of the Time to Conflict. When Aircraft A transitions to Sector 3 and Aircraft B transitions to Sector 4, the conflict changes from External to Inter-sector. Likewise, example 2 of the Inter-sector Conflict demonstrates that the conflict type changes to External when both Aircraft A & B have entered Sector 3.

EDA shall identify the type of each active and provisional conflict. The owner of each aircraft is the sector that has current control of that aircraft (independent of geometric location). The owner of each conflict is the sector within whose geometric boundaries the first loss of separation resides.

EDA shall also identify any sectors downstream of each aircraft that will be geometrically penetrated by either aircraft that are not one of the aircraft or conflict owners. For example, in Figure 3.2.4-3d, both sectors 3 and 4 will be penetrated (sector 6 owns the aircraft and sector 1 owns the conflict). Identification of these future sectors is important for alerting point-outs to neighboring sectors when an aircraft “clips the corner” of an adjacent sector (see Section 3.2.4.1.5).

External Intruder Conflict
Example 1

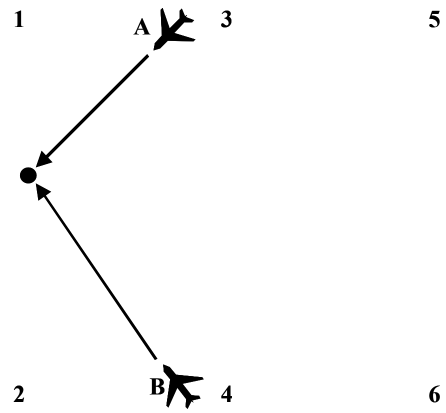

Figure 3.2.4-3a

External Intruder Conflict
Example 2

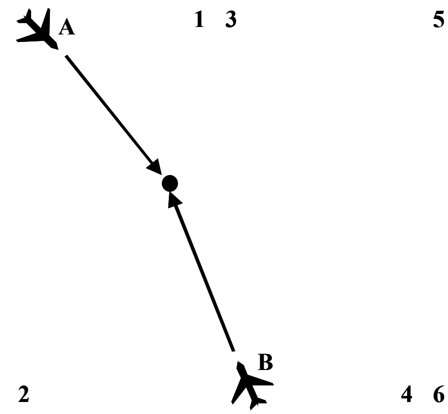

Figure 3.2.4-3b

External Conflict
Example 1

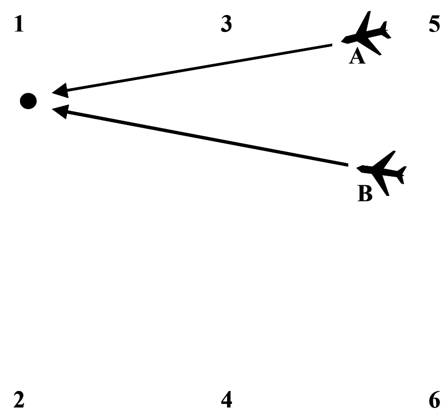

Figure 3.2.4-3c

External Conflict
Example 2

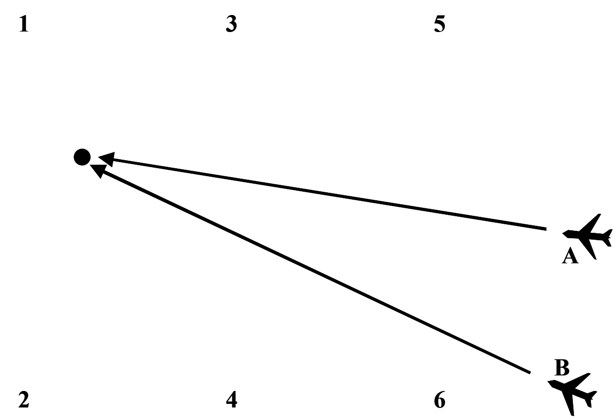

Figure 3.2.4-3d

Inter-sector Conflict
Example 1

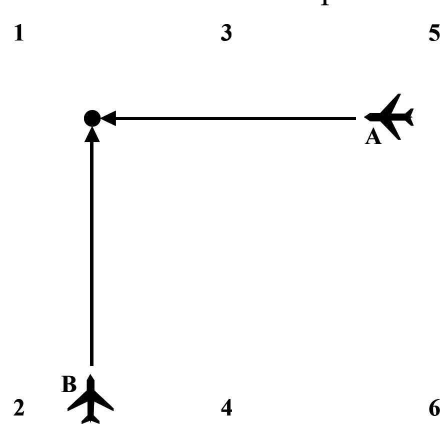

Figure 3.2.4-3e

Inter-sector Conflict
Example 2

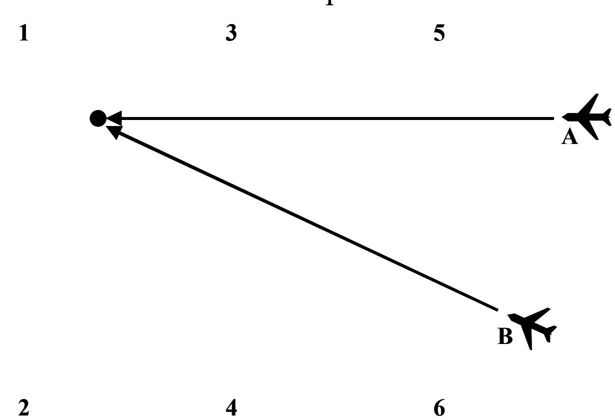

Figure 3.2.4-3f

Figure 3.2.4-3. Examples of Different Aircraft Conflict Types

3.2.4.1.3 Conflict Lists

Conflict Detection creates two conflict lists:

1. Active Conflict List (ACL)
2. Provisional Conflict List (PCL)

The ACL consists of all active conflicts visible to a sector. The PCL consists of all provisional conflicts visible to a sector. Neither dependency nor coordination alerts are a part of either list. These conflict lists are used by conflict resolution.

3.2.4.1.4 Conflict Location

In support of the algorithm illustrated in Section 3.2.4.2.9, the following definitions for conflict location are required:

1. Cruise Conflict - If the first loss of separation between two aircraft occurs in the cruise portion of flight for both aircraft, the conflict is defined as a cruise conflict.
2. Descent Conflict - If the first loss of separation occurs while either aircraft is in the descent portion of flight, the conflict is defined as a descent conflict.

3.2.4.1.5 Display of Conflict Information

A summary of the display of active/provisional conflicts and dependency/coordination alerts is shown in Table 3.2.4-1. The table shows which conflicts are displayed to a single controller (the "own" controller) and the classification type for each conflict. The chart supports all conflict types as well as all classifications.

Flow conformance trajectories are assumed provisional and automatically shared between neighboring controllers who have aircraft under the same flow conformance restriction. For example, flow conformance A could be a metering to Denver while flow conformance B could be spacing restrictions for Denver traffic into Minneapolis Center.

				AIRCRAFT A													
				Aircraft A owned by sector							Aircraft A owned by other sector						
				Active only	Active & prov*		Flow conformant Stream 1		Flow conformant Stream 2		Active only	Active & prov*		Flow conformant Stream 1		Flow conformant Stream 2	
				Active	Active	Prov*	Active	Prov**	Active	Prov**	Active	Active	Prov*	Active	Prov**	Active	Prov**
AIRCRAFT B	A/c B owned by sector	Active only	Active	AC	AC	PC	AC	PC	AC	PC	AC	AC	N/A	AC	N/A	AC	N/A
		Active & prov*	Active		AC	DA	AC	DA	AC	DA	AC	AC	N/A	AC	N/A	AC	N/A
			Prov*		DA	PC	DA	PC	DA	PC	PC	PC	CA	PC	CA	PC	CA
		Flow conformant Stream 1	Active				AC	DA	AC	DA	AC	AC	N/A	AC	N/A	AC	N/A
			Prov**				DA	PC	DA	PC	PC	PC	CA	DA	PC	PC	CA
		Flow conformant Stream 2	Active						AC	DA	AC	AC	N/A	AC	N/A	AC	N/A
			Prov**						DA	PC	PC	PC	CA	PC	CA	DA	PC
	A/c B owned by other sector	Active only	Active								AC†	AC†	N/A	AC†	N/A	AC†	N/A
		Active & prov*	Active									AC†	N/A	AC†	N/A	AC†	N/A
			Prov*									N/A	N/A	N/A	N/A	N/A	N/A
		Flow conformant Stream 1	Active											AC†	N/A	AC†	N/A
			Prov**											N/A	N/A	N/A	N/A
		Flow conformant Stream 2	Active													AC†	N/A
			Prov**													N/A	N/A

Table 3.2.4-1: Conflict Classification and Display to "Owning" Sector

AC = Active Conflict; PC = Provisional Conflict; DA = Dependency Alert; CA = Coordination Alert
N/A – not displayed to the "own" sector (displayed to "other" sector)
* Provisional trajectory that is not shared either manually or automatically
** Provisional trajectory based on flow conformance
† = Display active conflict only if one or both of the un-owned aircraft are within three minutes of penetrating the "own" sector boundary

Light green: aircraft with only active vs. aircraft with only active
Dark green: aircraft with only active vs. aircraft with active and provisional
Blue: aircraft with active and non-shared provisional vs. aircraft with active and non-shared provisional
Pink: aircraft with active and provisional flow rate conformance vs. aircraft with active and provisional flow rate conformance in same flow restriction [e.g., part of same metering]
White: aircraft with active and provisional flow rate conformance vs. aircraft with active and provisional flow rate conformance in different flow restriction [e.g., one metered and the other in spacing]
Yellow: aircraft with active and non-shared provisional vs. aircraft with active and provisional flow rate conformance

3.2.4.1.6 Configurable Settings

To support complete classification of potential conflicts, each combination of active plan trajectory and provisional plan trajectory for each aircraft pair must be probed for conflicts. EDA should be configurable (in a system setup panel) to remove computation and display of dependency and coordination alert classifications. The settings should be settable by each controller independently.

3.2.4.1.7 Requirements Statements

Number	Requirement Statement
CD-1	EDA shall assist controllers in the detection of aircraft separation assurance problems
CD-2	EDA shall detect separation assurance problems up to 20 minutes in the future (1-2 sectors)
CD-3	EDA shall integrate conflict detection with flow conformance advisories (metering and en route spacing)
CD-4	EDA shall provide planning, monitoring, and conformance tracking of separation assurance constraints
CD-5	EDA shall support distributed air/ground separation assurance
CD-6	EDA shall provide conflict detection for holding patterns by signaling potential conflict when an aircraft is predicted to pass near the oval-shaped airspace of the holding aircraft
CD-7	CD shall be fully configurable by controllers so that preferences can be set and saved.
CD-8	CD preferences shall include time horizon for detection (5-20 min) and separation minima (5-15 nmi)
CD-9	CD shall support metered and non-metered flights

3.2.4.2 Conflict Resolution

When an active or provisional conflict is detected, the resolution capability identifies whether a resolution advisory should be generated and, if so, generates a provisional plan trajectory for that aircraft that is conflict free (if possible). If the aircraft has a flow conformance constraint, then conflict resolution works with the flow conformance capability of EDA to generate a provisional plan trajectory that is both flow conformant and conflict free, if possible.

3.2.4.2.1 Resolution Advisories

If a conflict(s) has been identified for an aircraft, EDA provides two advisory generation modes for generating a provisional plan trajectory that resolves the conflict(s): Automatic and Semi-Automatic. In Automatic mode, EDA identifies all conflicts, determines which aircraft should maneuver to resolve each conflict, and automatically generates a provisional plan trajectory for the maneuver aircraft that resolves the conflict. In Semi-Automatic mode, advisory generation is not initiated unless a controller selects an aircraft for advisory generation. Whether in Automatic or Semi-Automatic mode, once advisory generation is initiated, degrees of freedom (DOF) are selected (see next) and a provisional plan trajectory to resolve the conflict is generated.

EDA provides three DOF selection modes for conflict resolution: Manual, Controller-Defined, and EDA-Defined. These modes are described below in Section 3.2.4.2.2. In manual mode, no DOF's are selected and EDA provides only conflict detection without resolution. Based on the conflict parameters (e.g., time to conflict, location of conflict), the controller enters active or provisional inputs to modify the aircraft's trajectory until the conflict is resolved. In Controller-Defined or EDA-Defined mode, a provisional plan trajectory is developed that resolves the conflict to the degree allowable by the selected DOF(s). Any conflicts unresolved by the provisional plan resolution trajectory are displayed to the controller. Each sector must be able to define its own resolution modes (advisory generation and DOF selection), independent of all other sectors.

During the development of provisional plan trajectories for conflict resolution, all other provisional inputs (except flow conformance advisories, as noted below) are accommodated. If a provisional input conflicts with the DOF selection mode (e.g., a provisional input exists for one of the DOFs available within the DOF selection mode), then the provisional input takes precedence. If all available DOFs within the DOF selection mode are over-ridden by provisional inputs, the aircraft trajectory is said to be "over-constrained" and resolution advisories are not generated.

If the aircraft being maneuvered is subject to a flow conformance constraint, conflict resolution must attempt to solve the detected conflict while maintaining flow conformance. See Section 3.2.4.2.3 for details on this integration.

Based on the final provisional plan trajectory, the advisories generated to resolve the conflict (and meet the STA for metered aircraft) are displayed to the controller for evaluation and possible manual modification. The controller can modify the resolution advisory by either changing the DOF selection mode for that aircraft or by entering active or provisional inputs. EDA shall update the resolution advisories (and metering if they exist) when changes are received.

3.2.4.2.2 Conflict Resolution DOF Selection Modes

EDA shall support three DOF Selection modes for conflict resolution:

1. Manual
2. Controller-defined
3. EDA-defined

Manual Conflict Resolution DOF Selection Mode

In manual mode, no DOFs are selected for advisory generation. EDA shall not generate a conflict resolution advisory, but shall provide separation assurance conformance checking (e.g., conflict detection) only.

Controller-Defined Conflict Resolution DOF Selection Mode

In controller-defined mode, the controller shall select the combination of DOFs that shall be applied to an aircraft for resolution advisory generation. A controller-defined resolution mode is either applied to an aircraft through a general setup parameter within EDA (e.g., setup panel that sets all arrival aircraft to default to altitude mode[7]) or through a controller input for that aircraft (e.g., switching a specific arrival aircraft from the default mode to a different resolution mode or

[7] As for flow conformance, it is anticipated that setup panels may be desired which defaults resolution DOF selection modes for groups of aircraft to specific modes.

adding a resolution mode if no default mode exists). Each aircraft within EDA must be able to have a unique conflict resolution mode.

There are three types of controller-defined resolution modes for EDA: speed, altitude, and lateral path. Only one mode within one of the three types can be selected for any one aircraft at any one time. EDA has two speed modes for resolution (cruise speed and descent speed), one altitude mode (cruise altitude) and one lateral path mode. The algorithms for these modes are TBD.

When performing conflict resolution on an aircraft with a flow conformance restriction, any degrees of freedom that are available within the aircraft's flow conformance DOF selection mode are available for resolution, adding to those defined by the controller for resolution without flow conformance. For example, if an aircraft is in "Cruise only" flow conformance DOF selection mode and has selected descent speed for its resolution DOF selection mode, both cruise and descent speed are available for resolution.

EDA-Defined Conflict Resolution DOF Selection Mode

In the EDA-defined resolution DOF selection mode, the controller elects to have algorithms within EDA choose an appropriate DOF(s) to resolve the conflict. In this mode, the controller shall be able to restrict certain DOFs from being selected by EDA, allowing EDA to choose from all remaining available DOFs.

The possible DOFs that should be available to EDA (and available for restriction by the controller) are:

1. Speed – including descent and cruise
2. Altitude
3. Lateral Path

When performing conflict resolution on an aircraft with a flow conformance restriction, any degrees of freedom that are available within the aircraft's flow conformance DOF selection mode are available for resolution, over-riding any restrictions defined by the controller for resolution without flow conformance. For example, if an aircraft is in "Cruise equals Descent" flow conformance DOF selection mode, but cruise speeds are restricted for resolutions, the restriction is over-ridden and both cruise and descent speed combinations are possible.

3.2.4.2.3 Resolution Manager: Top Level Conflict Resolution Algorithm

Conflict Resolution (CR) is separated into multiple levels of functional flow descriptions[8]. The principal level, referred to as *Resolution Manager*, primarily serves as the bookkeeper for the Active and Provisional Conflict Lists; adding and removing conflicts as necessary. Functional flow for *Resolution Manager* is shown in Figure 3.2.4-4.

Conflict Resolution receives the ACL and PCL as input from conflict detection. The initial action performed by *Resolution Manager* is to merge these two lists together into a single list of conflicts requiring resolution and to sort the resultant list by time to conflict (from earliest to latest), represented by *Sort Conflicts* as shown in Figure 3.2.4-4. This merged list is referred to as the Resolution Conflict List (RCL). The RCL is developed by adding ACL conflicts, in which neither aircraft has a provisional plan trajectory, to the PCL.

Once the RCL is created, Conflict Resolution cycles through the list, beginning with the earliest time conflict. Cycling through the RCL, Conflict Resolution finds a resolution solution for the current conflict. *Perform Resolution* represents the process of finding the best resolution solution.

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[8] The various levels of CR do not represent different levels of detail; Figures (X1-X6) could simply be combined into one large flow chart.

Functional flow for *Perform Resolution* is shown in Figure 3.2.4-5 and is discussed in Section 3.2.4.2.4. If a completely conflict free resolution trajectory was found for one of the aircraft involved in the current conflict, the current conflict is removed from the RCL. If the current conflict exists in the PCL, it is also removed from the PCL (e.g., the final provisional trajectory solves the original provisional conflict in the PCL). A search is then performed to remove all other conflicts from the RCL and PCL of which the maneuvered aircraft was a part (i.e., the new resolution maneuver removes all conflicts caused by the maneuvered aircraft's previous trajectory). The resolution maneuver for the current conflict may have created new conflicts, therefore a second search is performed that adds any newly created conflicts to the RCL and PCL. The conflict resolution cycle then moves on to the next conflict in the RCL.

Note that all conflicts involving the maneuver aircraft are initially removed from the RCL and PCL even though the maneuvered aircraft may still be in conflict with these aircraft. If the maneuvered aircraft is still in conflict with another aircraft, these conflicts are added into the RCL and PCL as newly created conflicts based on the resolution maneuver. This algorithm was chosen because; 1) It eliminates the problem of having to search through each conflict and determine whether or not it should be eliminated from the RCL and PCL, and 2) If conflicts other than the current conflict are not eliminated, the parameters of the conflict (including the time to conflict and minimum separation) are likely to change. It is possible that conflicts could be created by the resolution maneuver that occurs at an earlier time than the current conflict. These conflicts are inserted into the appropriate sequential location in the RCL. The cycle through the RCL from earliest time to conflict to latest insures that newly created conflicts at earlier than current conflict times are the next to be resolved in the cycle. Created conflicts below a set time-to-conflict tolerance are not allowed to be added by the *Perform Resolution* algorithm.

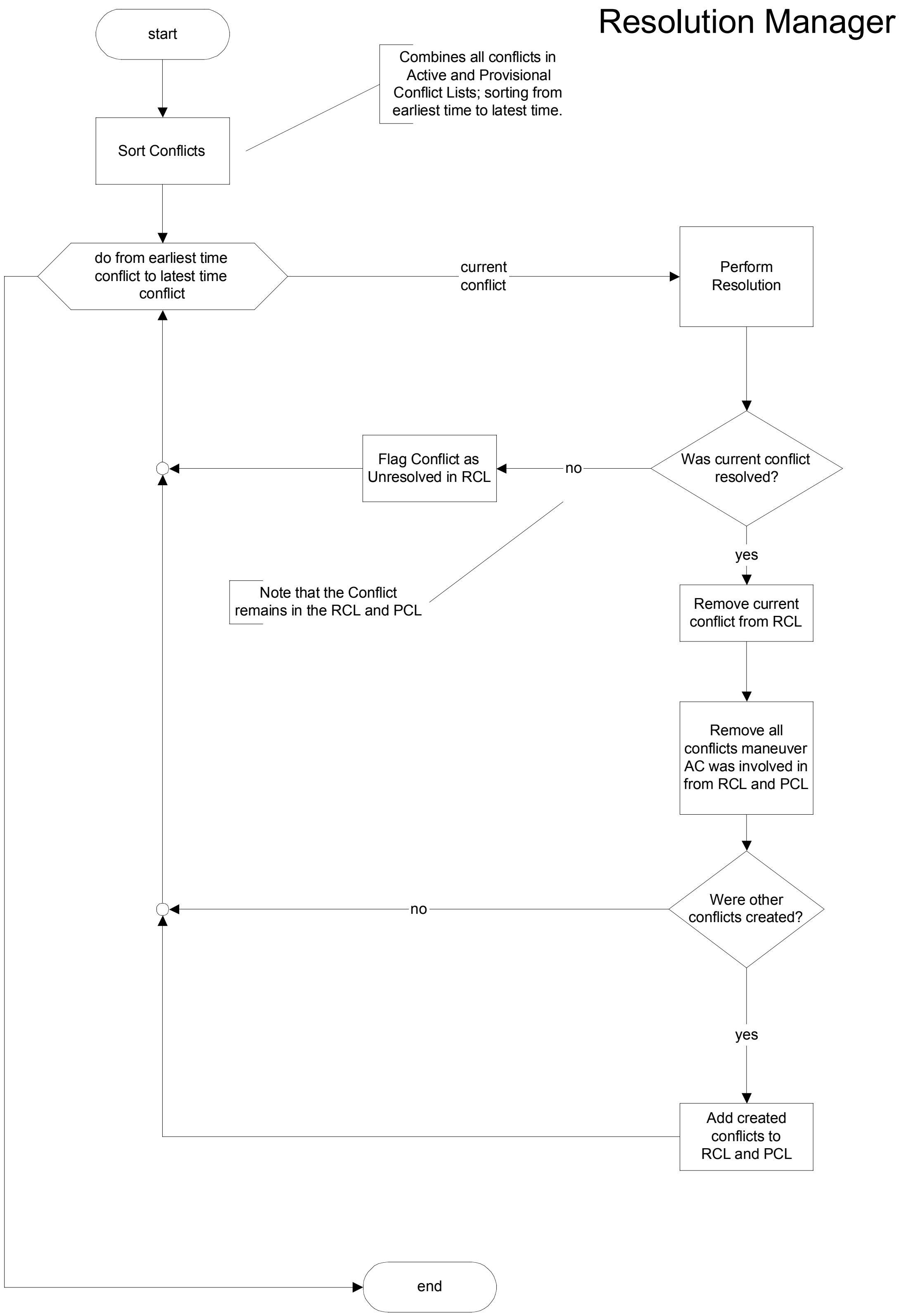

Figure 3.2.4-4. Functional flow for *Resolution Manager*

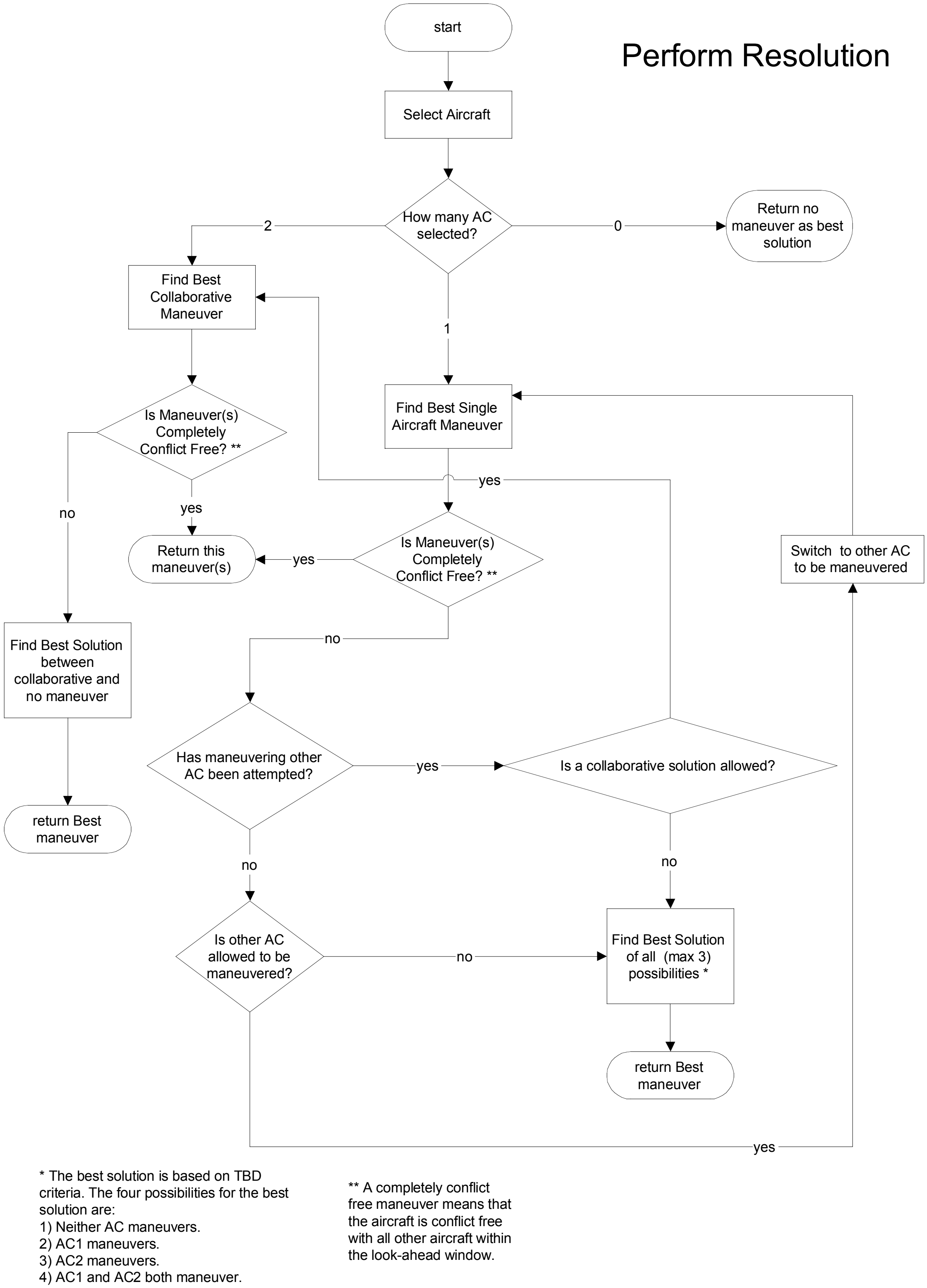

Figure 3.2.4-5. Functional flow for *Perform Resolution*

3.2.4.2.4 Perform Resolution

Perform Resolution is the process where the best resolution maneuver is found. It should be noted that this resolution maneuver may not necessarily be conflict free. The perform resolution function always attempts to find the "best" solution using both aircraft and all the degrees of freedom available to the algorithm, within the constraints imposed by the controller (e.g., through the advisory generation and DOF selection modes). In some cases where an improved maneuver cannot be found, the best maneuver may actually be the trajectories that were originally in conflict[9].

The first action within *Perform Resolution* is to determine the maneuver eligibility and preference for each aircraft in a conflict. This action is executed by the *Select Aircraft* function (functional flow for *Select Aircraft* is shown in Figure 3.2.4-6 and described in Section 3.2.4.2.5). *Select Aircraft* returns the number of aircraft that are to be maneuvered. If zero is returned, neither aircraft is eligible for maneuver and *Perform Resolution* returns no maneuver as the best solution.

If *Select Aircraft* returns one as the number of aircraft to be maneuvered, at least one aircraft is eligible for maneuver (the aircraft which is to be maneuvered is identified in *Select Aircraft*). The function *Find Best Single Aircraft Maneuver* is then called (functional flow for *Find Best Single Aircraft Maneuver* is shown in Figure 3.2.4-8 and described in Section 3.2.4.2.7). If a conflict free maneuver has been found by *Find Best Single Aircraft Maneuver* this solution is returned to *Resolution Manager*. If a conflict free maneuver was not found, a check is made to see if the other aircraft can be maneuvered. If the other aircraft cannot be maneuvered, the previous solution is compared with the option of no maneuver at all to see which is better. The better of the two is then returned to *Resolution Manager*. If the other aircraft can be maneuvered, *Find Best Single Aircraft Maneuver* is called for this aircraft. If the solution is conflict free, this solution is returned to *Resolution Manager*. If the solution is not conflict free, the option of a collaborative[10] solution is investigated. If a collaborative solution is not allowed, the two single aircraft maneuvers are compared with the option of no maneuvers and the best of those three options is returned to *Resolution Manager*. If a collaborative solution is allowed the function *Find Best Collaborative Solution*[11] is called. If the collaborative solution is conflict free, this solution is returned to *Resolution Manager*. If the collaborative solution is not conflict free, it is compared with the option of no maneuvers and the better of the two options is returned to *Resolution Manager*.

If *Select Aircraft* returns two as the number of aircraft to be maneuvered, the controller has requested a collaborative solution be attempted. The function *Find Best Collaborative Solution* is called. As described above if the collaborative solution is conflict free, this solution is returned to *Resolution Manager*. If the collaborative solution is not conflict free, it is compared with the option of no maneuvers and the better of the two is returned to *Resolution Manager*.[12]

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[9] This is an area of research. If there is a set of "best" criteria defined for a conflict, due to constraints on what degrees of freedom are used to resolve the conflict, it is possible that the best solution for this conflict is to perform no maneuvers at all. Further explanation for best solution criteria is given below.

[10] A collaborative solution is defined as a conflict resolution where both aircraft maneuver cooperatively in order to eliminate the conflict.

[11] Algorithm for *Find Best Collaborative Solution* is TBD.

[12] The algorithm for collaborative solutions is assumed to find a single aircraft solution if that is the best maneuver (this is the extreme of a collaborative solution). Therefore, the comparison between the collaborative and the single aircraft maneuvers is primarily done when the single aircraft maneuvers are performed first. This situation is expected if multi-aircraft maneuvers are considered a "last resort" due to the added workload of simultaneous maneuvering.

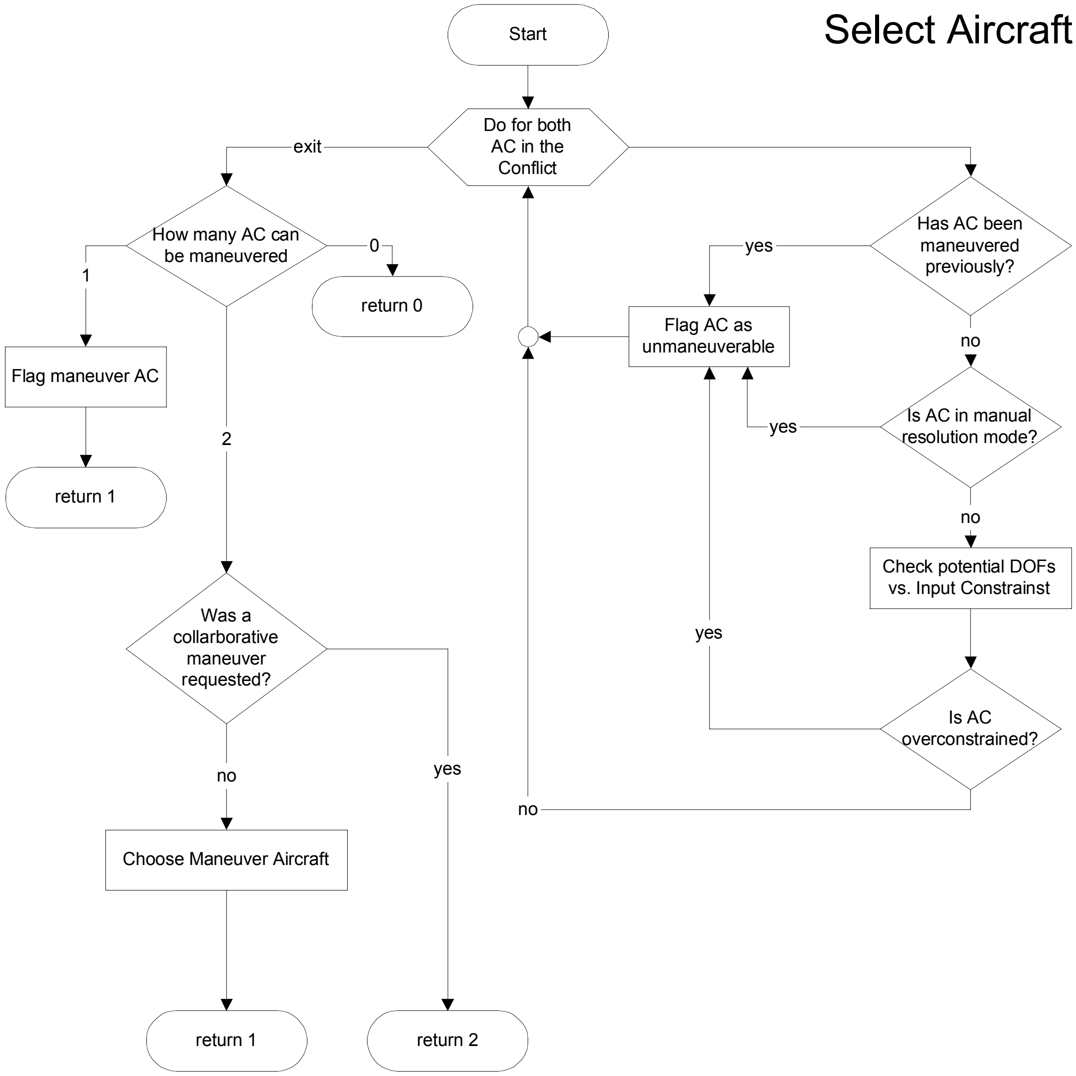

Figure 3.2.4-6. Functional Flow for *Select Aircraft*

3.2.4.2.5 Select Aircraft

Select Aircraft determines the maneuver eligibility for both aircraft in a conflict and if need be the maneuver order for both aircraft (i.e., which aircraft should maneuver). The first action within Select Aircraft is to determine the maneuver status of both aircraft in the conflict. If an aircraft: 1) Has previously been maneuvered during this cycle through the RCL, 2) Has been placed in Manual Resolution Mode, or 3) Is over-constrained (see Section 3.2.4.2.1), the aircraft cannot be maneuvered and is flagged as such.

The second action within *Select Aircraft* is to determine the maneuver order for the conflicting aircraft. If neither aircraft can be maneuvered, *Select Aircraft* returns zero. If one aircraft can be maneuvered, *Select Aircraft* identifies this aircraft as the maneuver aircraft and returns one. If both aircraft can be maneuvered, a check is made to see if a collaborative solution has been requested. If a collaborative solution has been requested, *Select Aircraft* returns 2. If a collaborative solution has not been requested, the function *Choose Maneuver Aircraft* is called (see Section 3.2.4.2.6 and Figure 3.2.4-7 for functional flow for *Choose Maneuver Aircraft*). This function identifies which aircraft should be maneuvered first. *Select Aircraft* then returns 1.

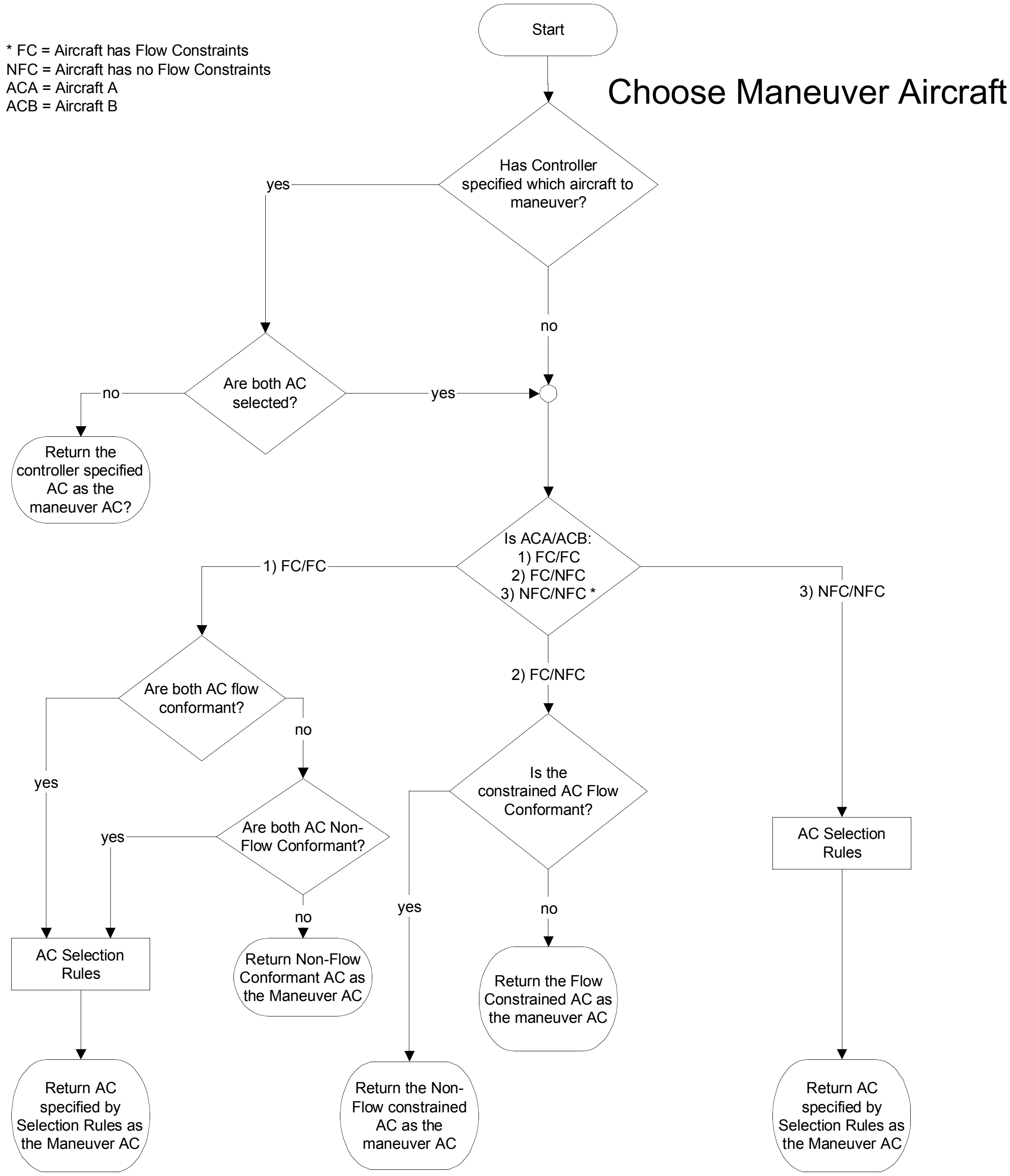

Figure 3.2.4-7. Functional Flow for *Choose Maneuver Aircraft*

3.2.4.2.6 Choose Maneuver Aircraft

Choose Maneuver Aircraft is invoked by *Select Aircraft* when both aircraft are allowed to maneuver. The first check performed within *Choose Maneuver* is whether the controller has specified one of the aircraft as the maneuver aircraft (e.g., semi-automatic resolution advisory mode). If one (and only one) of the aircraft has been specified by the controller, *Choose Maneuver* returns this aircraft as the maneuver aircraft. If both aircraft have been specified by the controller or neither aircraft has been specified by the controller the following rules are applied to determine the maneuver aircraft as shown in Figure 3.2.4-7[13].

If the conflicting aircraft are both flow constrained, the flow conformance status of each aircraft is checked. If one aircraft is flow conformant and the other is not, the non-flow conformant aircraft is selected as the maneuver aircraft. If both aircraft are flow conformant or not flow conformant the function *AC Selection Rules*[14] is called to determine which aircraft should maneuver. The AC Selection Rules are TBD except in the case where the conflict type is "External Intruder" (see Section 3.2.4.1.2). In the external intruder case, the aircraft owned by the sector who owns the conflict should be selected for maneuvering.

3.2.4.2.7 Find Best Single Aircraft Maneuver

Find Best Single Aircraft Maneuver returns the best resolution maneuver for a single aircraft resolution (i.e., the best non-collaborative solution). As shown in Figure 3.2.4-8, the first action performed by *Find Best Single Aircraft Maneuver* is case selection, performed by *Select Case* (see Figure 3.2.4-9 and Section 3.2.4.2.8). Cases are defined as follows:

Case 1: Find a flow conformant trajectory using a single degree of freedom (DOF). A new flow conformant degree of freedom is desired. No additional degrees of freedom are applied for conflict resolution.

Case 2: Find a conflict free trajectory using a single degree of freedom for conflict resolution. Flow conformance is ignored.

Case 3: Find a flow conformant trajectory that is conflict free using multiple degrees of freedom. One degree of freedom is used to resolve the conflict, another degree of freedom is used for flow conformance.

Case 4: Generation of a maneuver is not required. Case 4 is selected when the controller has specified the same (single) degree of freedom for both flow conformance and resolution (see description for *Select Case* and Figure 3.2.4-9).

If Case 1 is selected, the algorithm selects the degree of freedom that is to be used for flow conformance.[15] This degree of freedom is then passed to the Flow Conformance function (See EDA Functional Flow Diagram), which iterates values for this DOF in order to find a flow conformant trajectory, which is returned to *Find Best Single Aircraft Maneuver*. If this maneuver is flow conformant and conflict free, it is returned back to *Perform Resolution*. If either the flow conformance or conflict free criteria are not met, DOF selection is invoked again. If a new degree of freedom is available, it is passed to the Flow Conformance Function and the process is repeated. If there are no longer any degrees of freedom available, a switch is made to Case 3.

If Case 3 has been selected (either by *Select Case* or a switch from Case 1), the algorithm selects a degree of freedom for both conflict resolution and flow conformance. Degree of freedom selection will include controller input (controller-defined mode) as well as heuristics for automatic selection (EDA-defined mode). Degree of freedom selection algorithms are TBD. An algorithm for metered arrival aircraft is presented in Section 3.2.4.2.9. Once both resolution and

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[13] This logic is consistent with the final results for trajectory-oriented controller procedures developed within AATT Research Task Order 50: "En-route Controller Roles and Responsibilities in support of En route Descent Advisor Inter-sector Planning."
[14] Function *AC Selection Rules* is TBD. This function will take into consideration the number of other conflicts each aircraft has, flight rules, and heuristic criteria such as that given in reference 4.
[15] This algorithm is currently TBD. It is expected that the algorithm will identify other flow conformance DOFs available other than the initial one selected by the flow conformance advisory generation. The algorithm should ignore available DOFs that will not have an impact on resolution (e.g., selecting Cruise and Descent mode when Descent Only is flow conformant will return the same trajectory).

flow conformance degrees of freedom are selected a value for the resolution degree of freedom is chosen (The algorithm for choosing this value is TBD. An example for metered aircraft is given in Section 3.2.4.2.9). Once the resolution degree of freedom value is defined, it is passed on to the Flow Conformance function (where it is implemented as a constraint) along with the degree of freedom that was selected for flow conformance. The Flow Conformance algorithm iterates values for the flow conformance DOF searching for a flow conformant trajectory. The Flow Conformance function returns a solution back to *Find Best Single Aircraft Maneuver*. If the maneuver is not flow conformant, a new resolution degree of freedom is selected (as shown in Figure 3.2.4-8) and the process is repeated (a new resolution degree of freedom and most likely new flow conformant degree of freedom is selected if all resolution DOF values have been attempted). If the maneuver is flow conformant it is then probed for conflicts. If the maneuver is not conflict free, the same process is repeated as for the non-flow conformant maneuver. If the solution is both flow conformant and conflict free it is returned to *Perform Resolution*. Note that resolution and flow conformant DOF selection has memory of previous iterations and will not repeat solutions that have already been attempted. If all degree of freedom options for flow conformance and resolution have been exhausted, the best solution out of all DOF combinations is returned to *Perform Resolution* (see best solution description below).

If Case 2 has been selected, the first action is selection of the degree of freedom to be used for resolution. The actual value for this degree of freedom is defined next (algorithms for selection of the resolution DOF and determination of it's actual value are TBD). This resolution DOF value is passed to the Trajectory Generation function, which calculates the trajectory. This trajectory is then probed for conflicts. If the trajectory is conflict free, it is returned to *Perform Resolution*. If the solution is not conflict free, a new value is tested. This iteration is repeated until a conflict free solution is found or the DOF value has been maxed out (i.e., exceeds the allowable range). If the degree of freedom has been maxed out, a new DOF is selected (if available) and the iteration process is repeated. If all DOF options have been exhausted the best possible solution is returned to *Perform Resolution*.

As mentioned above for Case 2 and Case 3, if a solution cannot be found that is conflict free (Case 2) or conflict free and flow conformant (Case 3) the best possible solution is returned to *Perform Resolution*. For each degree of freedom combination under Case 3 and single DOF choice under Case 2, the best solution is stored in memory. If a solution is not found, the solution for each combination is compared and the best solution is sent to *Perform Resolution*. For example, under Case 2 a solution for 1) The best cruise calibrated airspeed solution, 2) The best altitude solution, and 3) The best path stretch solution would be stored in memory (assuming these were the three available degrees of freedom). The best out of those three solutions is returned to *Perform Resolution* (algorithms for determining the best solution are TBD[16]). For the conflict resolution/flow conformance combinations under Case 3, the best solution for each conflict resolution DOF/flow conformance DOF combination is stored in memory and the best out of all those solutions is returned to *Perform Resolution*.

[16] Best solution criteria will include number of conflicts the maneuver has, time to each conflict, and severity of conflicts. These criteria will also be applied to the best solution selection algorithms in *Perform Resolution*.

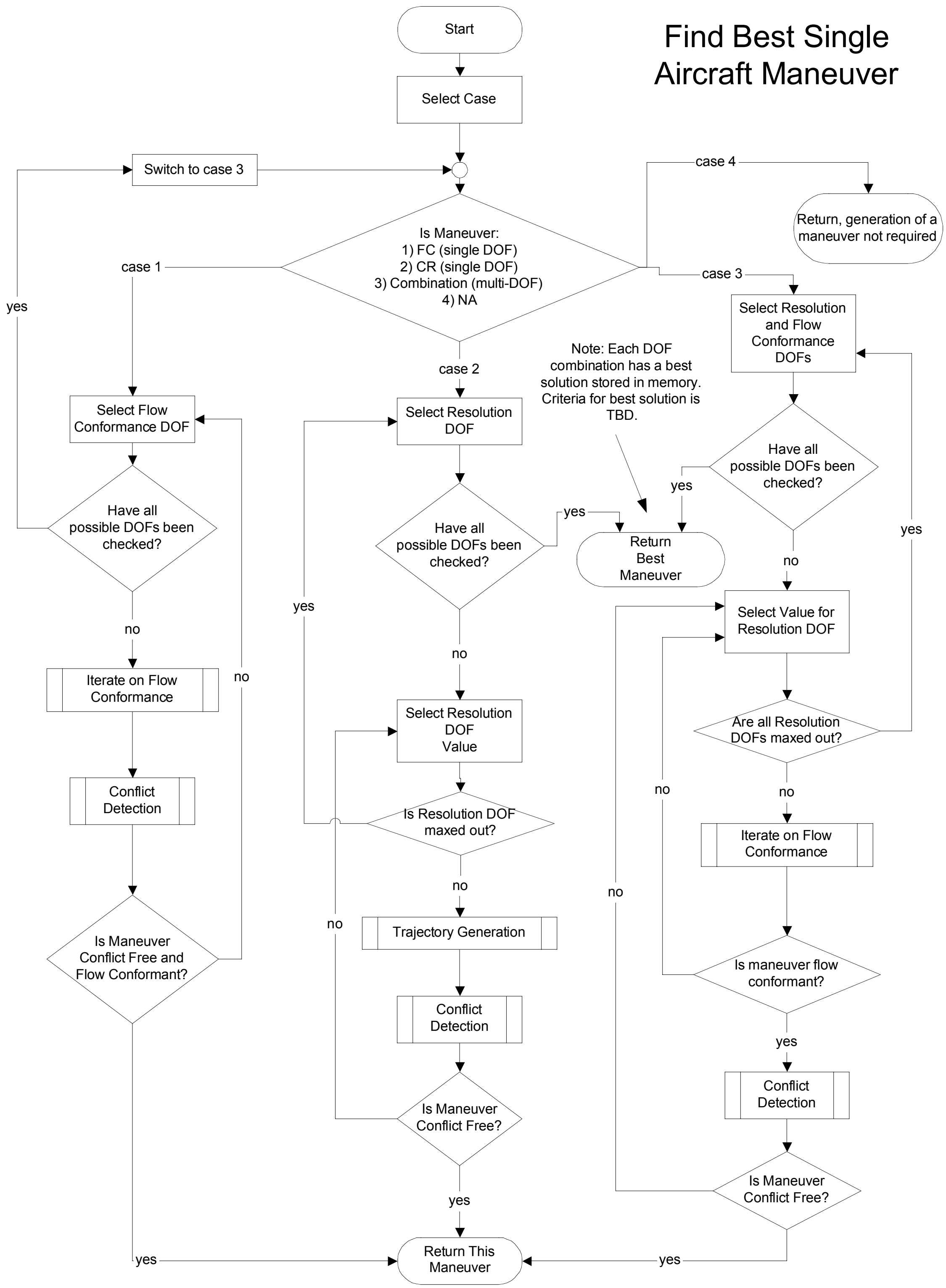

Figure 3.2.4-8. Functional flow for *Find Best Single Aircraft Maneuver*

3.2.4.2.8 Select Case

Find Best Single Aircraft Maneuver invokes Select Case in order to determine the appropriate Case required for maneuvering the selected aircraft (see Figure 3.2.4-9 for functional flow of *Select Case*). *Select Maneuver* receives as input indication of which aircraft is to be maneuvered. Determining the proper Case is based on the flow conformance and conflict resolution DOF selection modes specified by the controller (see Sections 3.2.2.3.1 and 3.2.4.2.2, respectively). The three possible modes are:

1) Manual (no DOF available)

2) Controller-Defined (controller specifies which DOF to use)

3) EDA-Defined (EDA determines which DOF to use)

The first action performed with *Select Case* is to determine if the maneuver aircraft possesses flow conformance constraints. If the aircraft does not possess any flow conformance constraints, then a single DOF resolution maneuver is all that is required. Therefore, for controller-defined and EDA-defined modes Case 2 is selected. Notice in Figure 3.2.4-9 that a manual mode is not applicable (since an aircraft with a manual conflict resolution mode selected would have been flagged in *Select Aircraft* as unmaneuverable) but is maintained in the flow chart for the sake of robustness and error protection. Case 4 is selected for manual conflict resolution mode, which is returned to *Find Best Single Aircraft Maneuver*, indicating that finding a resolution maneuver is not required.

If the maneuver aircraft does possess flow conformance constraints, the first check to be performed is for the conflict resolution mode. As described above, if the conflict resolution mode is manual, Case 4 is returned. If the conflict resolution mode is EDA-defined, the flow conformance mode is checked next. Under this decision branch (EDA-defined CR mode), if the flow conformance mode is manual Case 2 is selected (since flow conformance can be ignored). If the flow conformance mode is controller-defined, Case 3 is selected. If the flow conformance mode is EDA-defined, Case 1 is selected. The purpose of Case 1 is to attempt to solve a flow conformance/conflict resolution problem using only one degree of freedom. The premise of this is to attempt to find a quick single DOF solution to the problem and therefore attempt the higher workload multi-DOF solution (via Case 3) only if necessary. Case 1 is only possible for EDA-defined resolution and flow conformance modes because that is the only time the algorithm is free to choose both degrees of freedom automatically.

The final decision branch to be investigated is for the controller-defined CR mode. Under this branch, if the flow conformance mode is manual, Case 2 is selected. If the flow conformance mode is EDA-defined, Case 3 is selected. If the flow conformance mode is controller-defined and the (single) resolution degree of freedom selected by the controller is not the same as the (single) controller-selected flow conformance degree of freedom, Case 3 is selected. If the resolution and flow conformance degrees of freedom are the same, an advisory is sent to the controller that a maneuver cannot be generated due to the DOF incompatibility and *Select Case* returns Case 4.

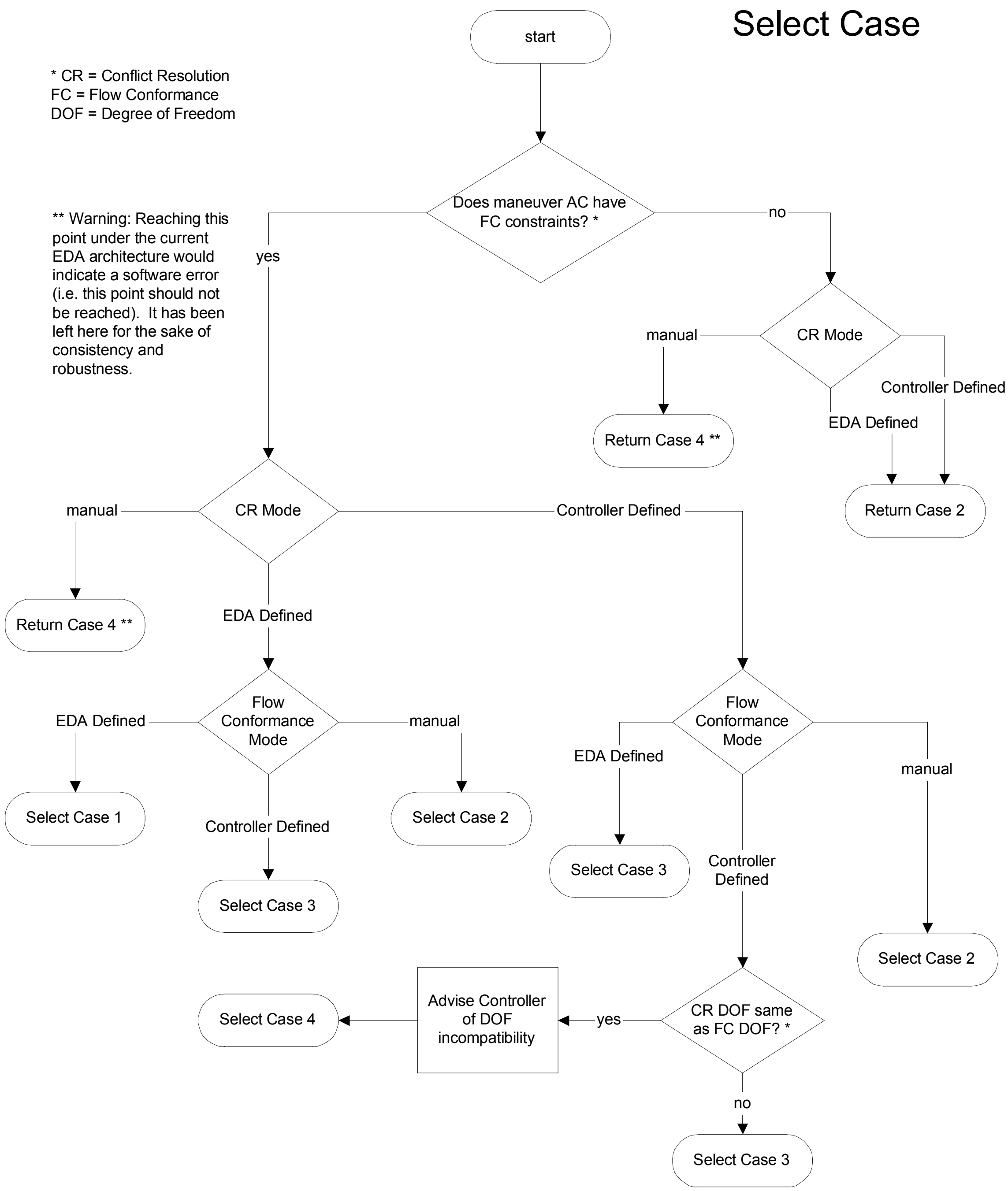

Figure 3.2.4-9. Functional flow for *Select Case*

3.2.4.2.9 Metered Arrival Resolution Algorithm

One automatic resolution algorithm that has been developed for EDA resolves a conflict when the maneuver aircraft is a metered arrival (see Slattery, reference [4]). This algorithm, though originally developed for EDA, needs to be updated to fit within the resolution structure defined above. The original functional flow diagram for this algorithm (reproduced from reference [4]) is given in Annex A. The dashed lines in the figure represent future extensions to the algorithm that were not implemented previously and are not implemented below.

The following description describes how to implement this algorithm within Build 3 EDA:

The selection of the maneuver aircraft (*Select Aircraft* in Figure 3.2.4-5: *Perform Resolution*) can occur in any method described above. This includes a semi-automatic resolution advisory mode where the controller selects a metered aircraft or selection of a metered aircraft by a TBD algorithm within an automatic resolution advisory generation mode. It is assumed that a collaborative resolution is not desired.

Within *Find Best Single Aircraft Maneuver* (Figure 3.2.4-8), *Select Case* (Figure 3.2.4-9) must return Case 3. This occurs when both the flow conformance DOF selection mode and the conflict resolution DOF selection mode are either controller-defined or EDA-defined.[17] Additionally, the algorithm requires that at a minimum, cruise speed and descent speed must be available through some combination of flow conformance and conflict resolution DOFs.[18] The complete algorithm will be exercised if altitude is also selected as either a Flow Conformance or Resolution DOF.

Figure 3.2.4-10 describes the required algorithm for *Select Resolution and Flow Conformance DOFs* in *Find Best Single Aircraft Maneuver* (Figure 3.2.4-8) for Case 3. Figure 3.2.4-11 describes the required algorithm for *Select Value for Resolution DOF* in *Find Best Single Aircraft Maneuver* (Figure 3.2.4-8) for Case 3. For traceability to the original flow chart given in the annex, all boxes highlighted in yellow are directly identifiable within the original flow chart.

As shown in Figure 3.2.4-10, the first action performed when selecting the conflict resolution and flow conformance degrees of freedom is to determine if a previously selected resolution degree of freedom has been maxed out (i.e., all possible values for that DOF have been investigated). It is assumed that on the initial call for selecting the conflict resolution (CR) and flow conformance (FC) DOFs, the CR DOF is not maxed out. Assuming this is the initial call, the next step is to determine if the maneuver aircraft is an arrival or non-arrival. If the aircraft is a non-arrival, the algorithm cannot be applied and a return of no available degrees of freedom is sent back to *Find Best Single Aircraft Maneuver.* If the maneuver aircraft is an arrival, cruise and descent speeds must be available as DOFs. If not, then no available DOF is sent back to *Find Best Single Aircraft Maneuver* and resolution is not performed. If these DOFs are available, the conflict type must be determined as either a cruise conflict or descent conflict (see Section 3.2.4.1.4). For a cruise conflict, the search direction used to iterate on the descent[19] calibrated airspeed (CAS) is calculated based on the cruise CAS of the two conflicting aircraft. For a descent conflict, the search direction is calculated based on the descent CAS of the two conflicting aircraft. The basic principle for choosing the search direction in either case (cruise or descent conflict) is based on the following: (1) if the maneuver aircraft is faster than the other aircraft in cruise, it is overtaking the other aircraft and it's cruise CAS should be slowed down (vice versa if it is slower), (2) if the maneuver aircraft is faster than the other aircraft in descent, it is overtaking the other aircraft, and its descent CAS should be slowed down (again, vice versa if it is slower). Once the search direction is found, descent CAS is selected as the resolution DOF and cruise CAS is selected as the flow conformant DOF. The value for descent CAS is set to the initial descent CAS value at this time. These DOFs are then returned to *Find Best Single Aircraft Maneuver.*

Figure 3.2.4-11 illustrates the algorithm for selecting the resolution DOF(s) value. The first time through, altitude (if selected as a potential resolution DOF) is ignored. Therefore, the first action

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[17] In the case of both DOF selection modes being EDA-defined, EDA Build 3 should return Case 3 until an algorithm for initially choosing Case 1, as shown in *Select Case* Figure X6, is developed.

[18] Slattery's algorithm assumed a flow conformance DOF selection mode of Cruise and Descent. In the new structure, any combination of flow conformance and resolution DOF selection modes that provide cruise and descent speed works (e.g., FC: Descent Only and CR: Cruise Only, FC: Cruise and Descent and CR: Descent Speed, etc.)

[19] Note that the algorithm given in reference 4 iterates using descent CAS as the CR DOF for both cruise conflicts and descent conflicts. Future algorithms are expected to iterate on cruise CAS for cruise conflicts and descent CAS for descent conflicts. Branches that are currently redundant are included in Figures X7-X8 to allow for these future modifications.

is to determine the conflict type as cruise or descent[20]. The descent CAS is then calculated based on the search direction determined earlier in Figure 3.2.4-10. The descent CAS is then checked to see if it has maxed out. If the descent CAS value has not been maxed out, it is returned to *Find Best Single Aircraft Maneuver*, which finds a cruise CAS value to meet the STA by calling the Flow Conformance function (as described earlier). If a conflict free, flow conformant solution is found that solution is returned as the final solution. If a conflict free, flow conformant solution is not found, the process of calculating the descent CAS based on the search direction is repeated until a conflict free, flow conformant solution is found or the descent CAS DOF has maxed out.

If the descent CAS degree of freedom has maxed out within *Select Resolution DOF Values*, altitude (if available) can be introduced as an additional resolution degree of freedom (descent CAS is also kept as a resolution DOF). If altitude is not available, the search for a solution failed and no resolution maneuver is returned. As shown in Figure 3.2.4-11, the initial time descent CAS maxes out, a check is made to determine if altitude has been selected as a DOF (which it hasn't yet; only *Select Resolution and Flow Conformance DOFs* can change the current DOFs). At this point, descent CAS is the only resolution DOF and it has maxed out; therefore control is returned to *Find Best Single Aircraft Maneuver* (Figure 3.2.4-8), which returns to *Select Resolution and Flow Conformance DOFs,* shown in Figure 3.2.4-10, to investigate introducing altitude as a resolution DOF.

The second time through *Select Resolution and Flow Conformance DOFs* (Figure 3.2.4-10), a resolution degree of freedom (Descent CAS) has just maxed out. The first action this time is to determine if altitude is an available degree of freedom. If altitude is available, it is checked to determine if it has been maxed out as shown in Figure 3.2.4-10. Since this is the initial check for adding altitude, the altitude has not been modified yet and therefore cannot be maxed out. Once this check is passed, altitude is added as an additional resolution degree of freedom. Note that descent CAS is also kept as a resolution DOF and the descent CAS search direction is maintained. If altitude were not available as a DOF or altitude was the DOF that maxed out (see below), then *Select Resolution and Flow Conformance DOFs* would return No DOF Available to *Find Best Single Aircraft Maneuver* and resolution would end.

If altitude is available and added as a resolution DOF, altitude and Descent CAS are passed to *Select Resolution DOF Values*, shown in Figure 3.2.4-11. Since this is the first iteration with altitude selected as a DOF, the first action is to reduce the altitude and check to verify that it is not below a minimum tolerance. If the altitude is within limits, the descent CAS is reset to its initial value[21]. The new altitude and descent CAS values are then sent back to F*ind Best Single Aircraft Maneuver*, which iterates on the cruise CAS value (as earlier) searching for a conflict free, flow conformant solution by calling the Flow Conformance function.

If a conflict free, flow conformant solution was not found, *Select Resolution DOF Values* is executed again. Since this is not the first iteration with altitude as a DOF, the first action is to determine the conflict type and find a new descent CAS based on the search direction.[22] Altitude is not decremented again until the Descent CAS is maxed out for this altitude (i.e., altitude represents an "outer loop" for iteration where Descent CAS is an "inner loop"). If the new descent CAS value has not maxed out, the descent CAS and altitude are again sent as constraints to *Find Best Single Aircraft Maneuver* for flow conformance iteration. If the search for a conflict free, flow conformant solution is once more unsuccessful, this process is repeated until a solution is found or the descent CAS maxes out.

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[20] Cruise and descent conflicts are again split here in order to allow for future modifications to the algorithm. Under the current implementation they perform the same actions.

[21] Future modifications to the algorithm are expected to use descent and cruise CAS for flow conformant DOFs rather than resetting descent CAS to its initial value.

[22] The algorithm uses altitude to either directly solve a cruise conflict (should find a conflict free trajectory the first time the altitude is changed) or to change the dynamics of the cruise and descent speed iteration to create more flexibility in solving a descent conflict.

If the descent CAS does max out, the next action is to reduce the altitude further, as shown in Figure 3.2.4-11. The altitude is then checked to determine that it is not below the minimum tolerance and the descent CAS is reinitialized. These new DOF values are then sent to *Find Best Single Aircraft Maneuver* and used as constraints for the flow conformance iteration. If the flow conformance iteration again fails, the “change descent CAS until it maxes out then change altitude” iteration process is repeated.

The iteration using altitude and descent CAS continues until a solution is found or the altitude goes below the minimum tolerance. Once the altitude has dropped below the minimum tolerance, control is returned to *Find Best Single Aircraft Maneuver*, which results in an affirmative that all DOFs have been maxed out. In *Select Resolution and Flow Conformance DOFs* (Figure 3.2.4-10), a resolution DOF (altitude and descent CAS) has maxed out and altitude is a DOF. A check is then made to see if altitude has maxed out. In this case, altitude has maxed and a return of no DOFs available will be sent to *Find Best Single Aircraft Maneuver*, which results in no resolution maneuver solution.

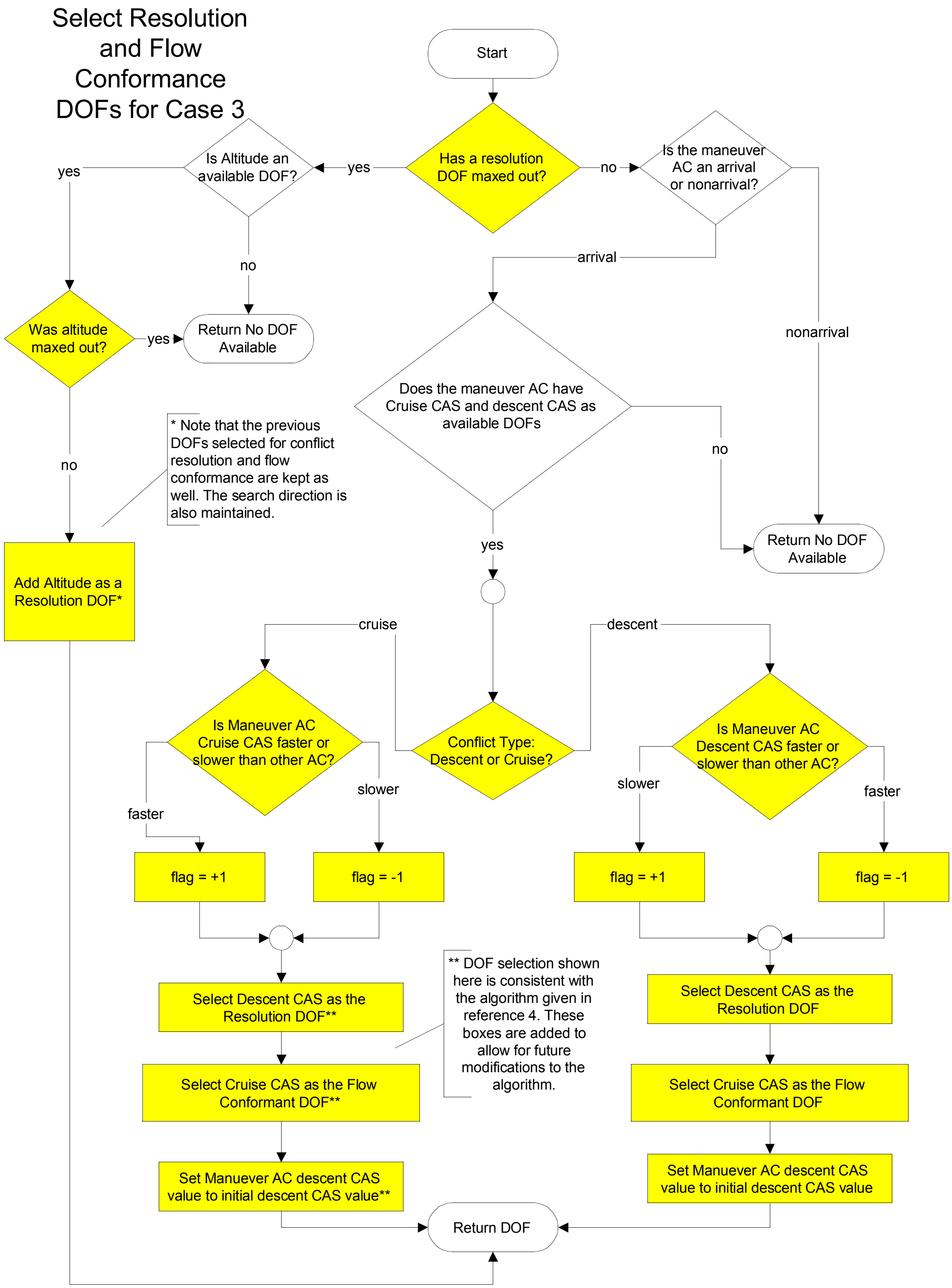

Figure 3.2.4-10. Functional flow for *Select Resolution and Flow Conformance DOFs* algorithm as applied to maneuver aircraft that are metered arrivals

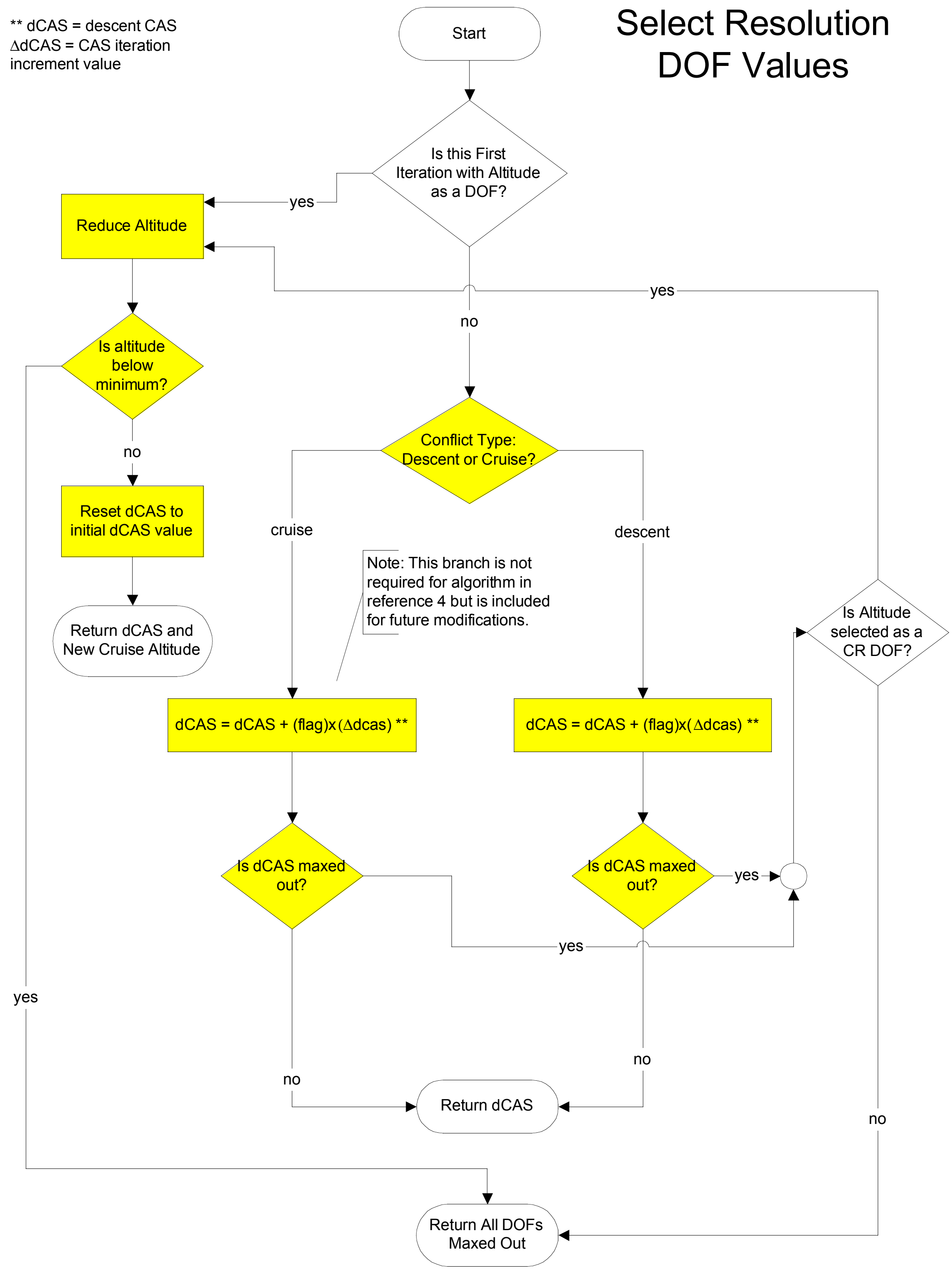

Figure 3.2.4-11. Functional flow for *Select Resolution DOF Values* algorithm as applied to maneuver aircraft that are metered arrivals

3.2.4.2.10 Requirements Statements

Number	Requirement Statement
CR-1	EDA shall assist controllers in the resolution of aircraft separation

	assurance problems
CR-2	EDA shall integrate conflict resolution with flow conformance advisories (metering and en route spacing)
CR-3	EDA shall provide automatic, semi-automatic, and manual conflict resolution modes
CR-4	EDA shall provide all three resolution modes in a hybrid system
CR-5	Automatic resolution shall generate advisories without requiring a dynamic controller input
CR-6	Semi-automatic resolution shall generate advisories after the controller dynamically selects the aircraft and advisory type (i.e., DOF)
CR-7	Manual resolution shall enable the controller to evaluate the impact of a series of dynamic inputs on a conflict
CR-8	EDA shall provide planning, monitoring, and conformance tracking of separation assurance constraints
CR-9	EDA shall provide "active" advisories to resolve separation assurance problems
CR-10	EDA shall support distributed air/ground separation assurance
CR-11	EDA shall accept manual controller adjustments to flow rate conformance advisories for conflict resolution
CR-12	CR shall be fully configurable by controllers so that preferences can be set and saved.
CR-13	CR preferences shall include time horizon for resolution (5-20 min)
CR-14	CR will support metered and non-metered flights
CR-15	CR will maximize FMS utilization
CR-16	CR will minimize necessary deviations from user preferences

3.2.5 User Trajectory Negotiation

EDA functional capabilities for user trajectory negotiation are TBD. User preferred provisional plan trajectories are sent from the aircraft to the controller via datalink. The controller will evaluate these user trajectories in the same manner as a shared provisional trajectory from another controller (see Section 3.2.1.2). The controller will then negotiate with the user, sending clearances directly to the aircraft via datalink. A design and evaluation of the ground-based portion of the air-ground datalink system will ultimately be based on previous EDA development in air-ground integration, see reference [5].

3.2.5.1 Requirements Statements

Number	Requirement Statement

TN-1	EDA shall support user trajectory negotiation
TN-2	EDA shall integrate with user (FMS & AOC) DST capabilities to enable trajectory negotiation
TN-3	EDA shall support the integration of user preferences during user negotiation
TN-4	EDA shall communicate with the FMS via datalink
TN-5	EDA shall adapt trajectory predictions to individual flight preferences (e.g., speed profile, routing, altitude profile, and time)
TN-6	EDA shall provide users with updates of the states of the ATM system (e.g., delay)
TN-7	EDA shall share key data with FMS-equipped aircraft to improve the trajectory predictions of EDA and FMS (e.g., wind and weight)

3.2.6 Intent Inferencing

TBD

3.2.6.1 Requirements Statements

Number	Requirement Statement
II-1	EDA shall infer intent from the information available to EDA including radar track, flight plan amendments, EDA advisory modes, and controller inputs
II-2	EDA shall determine the intended route/altitude/speed profile from the inferred intent in support of trajectory predictions
II-3	EDA shall consider controller intent, pilot-discretion intent, and pilot-deviation intent
II-4	EDA shall use heuristics and controller inputs to identify missing intent.
II-5	EDA shall use intent inferencing prior to developing controller plans

3.3 System External Interface Requirements

3.3.1 Interface Identification and Diagrams

3.3.1.1 Hardware/Software Interfaces

EDA shall utilize the existing two-way interface between CTAS and the Host. Additions shall include specific message requirements to pass interface information to the DSR. The specific requirements for DSR support will be developed as the EDA interface design (Section 3.3.1.2) is further defined.

3.3.1.2 EDA User Interface

3.3.1.2.1 Background

This section provides a description of the Graphical User Interface (GUI) for the En Route Descent Advisor (EDA). The GUI provides the controller the information available from the EDA and allows the controller to interact with and control the system. This GUI was designed to be implemented on the Display System Replacement (DSR) hardware located in Air Route Traffic Control Centers (ARTCC).

This specification assumes that, unless otherwise noted, capabilities existing in the current CTAS baseline (December 2000) will be retained. The appearance and operation of the existing capabilities will be altered so as to be consistent with the windows and tools described here.

Users

This GUI was designed to allow air traffic controllers to make use of the features and capabilities of the EDA. The GUI was designed for use by R-side controllers (radar-side) controllers, as opposed to D-side (data-side) controllers. These controllers work in ARTCCs (a.k.a., "centers"). Ultimately, EDA will support both R- and D-side controllers.

Target Hardware

The expected display is the Display System Replacement (DSR) used by the R-side controller. The main radar display in DSR is a full color, 20-inch by 20-inch display with 2000 row by 2000 column resolution. The controller interacts with the DSR workstation through a cursor control device (specifically a trackball) containing three (3) buttons and through a custom keyboard. Additionally, there are two smaller touch-screens through which the controller interacts with the voice communications systems. These touch-screen displays are not used to display radar information. The main radar display in DSR does not currently include support for interface devices such as a touch-screen or a light pen, nor does it support natural language recognition or voice synthesis.

Development System

While the DSR is the ultimate target hardware, it is expected that EDA will be first developed in a research, development, test, and evaluation (RDT&E) environment using commercially available workstations (i.e., Sun workstations). There will be a number of areas where the capabilities of the RDT&E environment differ from the DSR environment, at least in terms of the human-system interface. For example, it is likely that a multi-button mouse will be used to control the cursor in the RDT&E environment, rather than a trackball in the DSR environment. These small differences are not considered to be impediments to conducting initial controller-in-the-loop evaluations of the EDA.

3.3.1.2.2 Key EDA Functionality

Active and Provisional Planning

An aircraft always has an active plan. The active plan is the trajectory that the aircraft is expected to follow given the current flight plan, intent of the aircrew, and the intent of the controller. The active plan is most similar to the aircraft trajectory currently shown on the controller's radar display.

In addition to an active plan, an aircraft may have, but is not required to have, one provisional plan. A provisional plan is a possible trajectory for the aircraft. It may be manually created by the controller who "owns" or, in the case of trajectory negotiation, by the aircrew. In some cases, a provisional plan may be manually created by a controller who does not own the aircraft (for example, when controllers are cooperatively resolving a conflict involving a mixture of "owned" and "unowned" aircraft). One can think of a provisional plan as a possible clearance that is being evaluated by the controller to determine whether or not it fulfills the metering requirements while avoiding or eliminating airspace conflicts.

Conflict Probing and Deconfliction

EDA identifies conflicts that exist or are expected to exist in the future. The GUI displays this information to the controller, and provides the controller the means to resolve the conflict. The GUI also allows the controller to set the length of time probed, from 5 minutes ahead to 20 minutes ahead. The GUI also allows the controller to select between automatic, semi-automatic, and manual modes of conflict resolution.

Metering

EDA provides the controller information about the progress of an aircraft towards a reference point (e.g., a metering fix). EDA allows the controller to manually alter one or more of the aircraft's degrees of freedom to correct the time of arrival at the fix. It also allows the controller to have EDA generate a recommended profile. The controller may specify the degree(s) of freedom that EDA is allowed to use to generate a metering solution.

3.3.1.2.3 Screen Layout

This section identifies and briefly describes the key windows that shall appear on the EDA screen. The individual windows are described in greater detail in a subsequent section.

Figure 3.3.1-1 shows the overall layout of the EDA display. (Although this figure is not drawn to scale, it shows the general layout of the screen.) This display is presented on the DSR's Situation Display View screen.

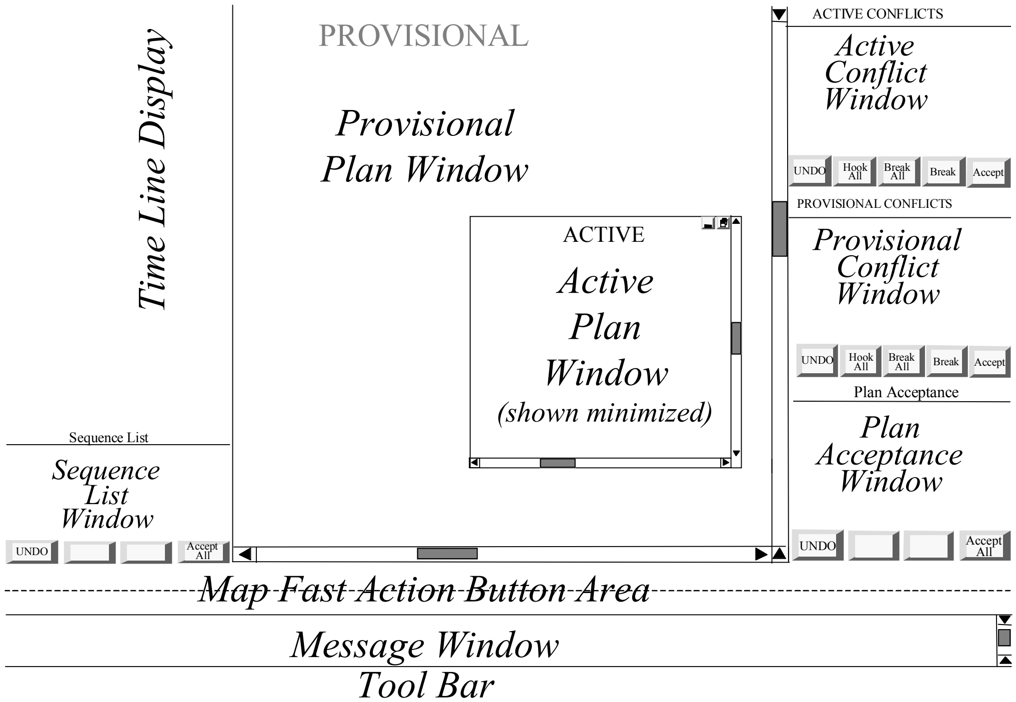

Figure 3.3.1-1. Layout of the EDA display

Window Sizes

The areas on the screen and approximate dimensions are:

- Time Line Display (Fixed size: 3 in [7.6 cm] wide by 11 in [35.6 cm] tall)
- Active Plan Window (Maximum size: 14 in [35.6 cm] wide by 14 in [35.6 cm] tall. The minimum size to which the controller can shrink the window: 5 in [12.7 cm] wide by 5 in [12.7 cm] tall, as shown in Figure 3.3.1-1.)
- Provisional Plan Window (Fixed size: 14 in [35.6 cm] wide by 14 in [35.6 cm] tall)
- Map Fast Action Button Area (Fixed size: 20 in [50.8 cm] wide by 2 in [5.1 cm] tall)
- Active Conflict Window (Fixed width, can be changed in height: 3 in [7.6 cm] wide)
- Provisional Conflict Window (Fixed width, can be changed in height: 3 in [7.6 cm] wide)
- Sequence List (Fixed size: 3 in [7.6 cm] wide by 3 in [7.6 cm] tall)
- Plan Acceptance Window (Fixed width, can be changed in height: 3 in [7.6 cm] wide)
- Message Window (Fixed size: 20 in [50.8 cm] wide by 3 in [7.6 cm] tall)
- Tool Bar (Fixed size: (20 in [50.8 cm] wide by 1 in [2.5 cm] tall)

The dimensions given above were determined by estimating the area needed to display the information in the various windows given the desire to provide the largest possible size for an area in which the active and provisional plans could be displayed.

Window Descriptions

This section contains brief descriptions of the information presented in each of the windows on the EDA screen.

Time Line Display

The time line display shows the STA and ETA of the aircraft that are being metered. It is also the window in which the "provisional ETA" (i.e., the ETA if the current provisional plan was to be made active) is displayed. The time line covers a period of 1 hour, with the current time at the bottom of the window. The call sign of an aircraft scheduled to arrive at a metering fix (or other designated point) 15 minutes from the current time would appear one quarter of the way up the screen. Similarly, the call sign of an aircraft scheduled to arrive in 40 minutes would appear two-thirds of the way up the window. (This presentation is adapted from the display in CAST.)

When the Sequence List Window is hidden, the Time Line Window is expanded so that it is the same height as the map display area (i.e., 14 in [35.6 cm]).

Active Plan Window

The Active Plan Window is the primary display used by the controller. A plan view (i.e., a "God's eye view") of the airspace is shown in this window. Each aircraft will have one, and only one, active plan. The ground path of the aircraft's active plan, including changes in direction anticipated based on intent, is shown in this window.

The Active Plan Window normally occupies the entire area designated for map displays, although the controller may reduce the size of the Active Plan Window so as to allow portions of the Provisional Plan Window to be viewed. In Figure 3.3.1-1 the Active Plan Window has been reduced in size, and the Provisional Plan Window occupies the full area designated for map displays.

Controllers may make changes to the active plan of an aircraft that they "own" in the Active Plan Window.

This window is located near the Sequence List Window. This keeps information regarding metering performance in the same region of the display.

Provisional Plan Window

The controller uses the Provisional Plan Window to prepare and evaluate provisional plan trajectories (see Section 3.2.1.2). The Provisional Plan Window shall be partially or completely occluded by the active plan window. When the Provisional Plan Window is displayed, it shall fill the area designated for map displays.

Map Fast Action Button Area

The Map Fast Action Button Area contains two rows of buttons. The upper row allows the controller to make changes to the Active- or Provisional Plans for a specific aircraft. Examples include making airspeed changes, and eliminating crossing restrictions. These buttons work on an aircraft's Active Plan when the aircraft is hooked in the Active Plan Window, and on the Provisional Plan when the aircraft is hooked in that window. The lower row of buttons allows the controller to configure the appearance to the Active and Provisional Plan Windows. Examples include buttons that control the display of wind direction and velocity, weather such as rain and turbulence, geographic boundaries, and special use airspace boundaries such as military operations areas.

Active Conflict Window

This window contains the Active Conflict List (See Section 3.2.4.1.3).

Provisional Conflict Window

This window contains the Provisional Conflict List (See Section 3.2.4.1.3).

Sequence List Window

The sequence list contains information related to the flow conformance of all aircraft, “owned” and “unowned” in the metering stream. This information includes the aircraft ID, the length of time the aircraft’s Expected Time of Arrival (ETA) using the active plan is ahead of or behind the Scheduled Time of Arrival (STA) (i.e., active delay), the amount of time the aircraft’s ETA using the provisional plan (if there is a provisional plan) is ahead of or behind the STA (i.e., the provisional delay), and the ETAs based on the active and provisional plans.

The Sequence List is an optional window. The controller shall have the capability to hide this window from view. When this window is hidden, the Time Line Window is expanded in height to the same height as the map area.

Plan Acceptance Window

This window contains the tools that a controller uses to make a provisional plan, or parts of a provisional plan, active.

Message Window

This area is used to display text indicating:

- A proposed provisional plan has been received via data link
- Electronic versions of an aircraft’s flight route sheet
- Information about an aircraft called up automatically when the cursor dwells over the aircraft
- Detailed information about an aircraft called up explicitly by a controller action (e.g., clicking on the trackball’s B-Button when the cursor is over the aircraft symbol or identifier.)

The controller can cut values from this window and past them into data fields in the Flight Data Blocks of the Active- or Provisional Plans.

Tool Bar

The tool bar contains buttons used by the controller to configure the GUI to suit personal preferences and to select among various options. Some of the buttons (e.g., UNDO) perform a single function. Other buttons cause a pop up menu containing either sets or related tools or a menu with options among which the controller selects.

Controller Operation of Windows

<u>Time Line Display</u>

This window shall always be displayed. It shall be positioned along the left side of the screen. The controller shall not have the ability to resize or reposition this window.

Figure 3.3.1-2 shows an example of the Time Line Display. This display is based on the time line display in the CAST demonstration. The EDA Time Line Display contains three columns. The left hand column shows the Scheduled Time of Arrival (STA) for each aircraft in that metering stream. The center column shows the Estimated Time of Arrival (ETA) of each aircraft based on the active plan of that aircraft. The right hand column contains the ETA based on the aircraft's provisional plan, if the aircraft has a provisional plan. If an aircraft does not have a provisional plan, there is no entry in the right hand column.

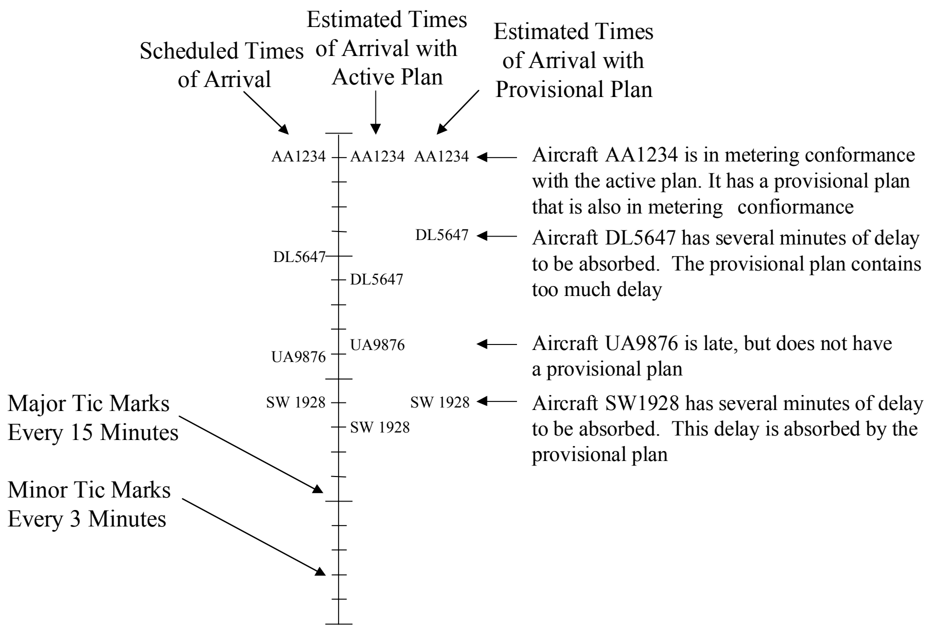

Figure 3.3.1-2. Time Line Display

Highlighting

When the controller hooks an aircraft the aircraft's identifiers shall be highlighted in all columns in this window, and in all other windows. Similarly, if the controller hooks an aircraft in another window that aircraft shall be highlighted this window as well.

ETAs Based on Provisional Plans

When a controller has prepared a provisional plan for an aircraft, the ETA of that aircraft based on the provisional plan, which is being called the "provisional ETA", shall be displayed. When an aircraft does not have a provisional plan, then there shall be no entry for that aircraft in this third column.

When the provisional plan for an aircraft is made active, then the ETA for the new active plan (i.e., the ETA of the new active plan) shall be displayed (active ETAs are always display) and the entry for the provisional plan shall be removed from the display.

The position of the aircraft identifier in the third column is expected to vary as the controller develops the provisional plan for an aircraft. For example, consider a case where an aircraft is on schedule (i.e., the STA and ETA from the active plan were the same) and the controller prepares provisional plan in which the only change is an increase in the aircraft's speed. In this situation an entry for that aircraft would appear in the third column. This entry would be positioned to show that the ETA using the provisional plan was earlier (farther down on the screen) than either the STA or the ETA using the active plan.

Drill Down

The controller shall have the capability to "Drill Down" and obtain more detailed data regarding metering conformance of an aircraft through the Time Line Display. When the controller places the cursor over the ACID in any of the columns of the time line display and clicks the B-button then details of the active and provisional plan (if a provisional plan exists) shall be displayed in the message window.

Additionally, if the controller has configured the display so that a metering list window is displayed, when the controller hooks the aircraft in the Time Line Display, the metering list shall automatically scroll (if necessary) so that the row of data on the hooked aircraft is visible to the controller.

Color Coding

The Time Line Display shall use color coding to aid the controller in identifying the "owned" aircraft, and in determining whether the "owned" aircraft are in conformance, ahead, or behind schedule.

"Un-owned" aircraft shall be displayed in white. "Un-owned" aircraft shall appear to be less bright than "owned" aircraft.

The Scheduled Time of Arrival (STA) of "owned" aircraft shall be a white color. This shall appear to be brighter than the "un-owned" aircraft. The active Expected Time of Arrival (ETA) of the aircraft shall be the same brightness and hue when the aircraft's active ETA is within TBD seconds of the STA. The active ETA shall be a pink hue when the aircraft is ahead of schedule and shall be a blue hue when the aircraft is behind schedule.

The provisional ETA of the aircraft shall be the same brightness and hue when the aircraft's provisional ETA is within TBD seconds of the STA. The provisional ETA shall be a pink hue when the provisional plan would result in the aircraft being ahead of schedule and shall be a blue hue color when the provisional plan would result in the aircraft being behind schedule.

Note that the color coding of the active and provisional ETAs are independent. The aircraft's active ETA could be earlier than its STA and the provisional ETA could be later than its STA, or vice versa, or the active and provisional ETAs could both be earlier or later than the STA.

In order to facilitate evaluation of alternative color coding options, the controller shall have the capability to configure the colors through the System Setup menus. However, in an operational system a set of consistent color conventions should be adopted within a Center, rather than allowing each controller to select a unique color coding scheme. Therefore, in the operational system consideration should be given to not including a color selection control.

Active Plan Window

Location of the Active Plan Window

The Active Plan Window shall always be displayed on the screen. It shall appear to be in front of the Provisional Plan Window, and shall be opaque. The controller shall have the ability to resize the window within limits, and shall have the ability to reposition the window within the area designated for map displays. Tool windows may be placed over the Active Plan Window by the controller if they are transparent. (The capability to place tool and information windows over the radar display is currently in DSR. However, DSR currently allows these windows to be either opaque or transparent. [Controllers typically configure the windows to be transparent.] In EDA these windows must be transparent.)

Expanding the Active Plan Window

The controller shall have the ability to expand the Active Plan Window to occupy the entire area designated for map displays (i.e., the area occupied by the active and provisional plan windows in Figure 3.3.1-1) with a single action at any time. Expanding the window shall be accomplished by clicking on an expand button located in the upper right corner of the window with the A-button on the trackball. When the window is fully expanded the expand button shall be "grayed out" and clicking on the button shall have no effect.

A button on the keyboard shall also be dedicated to expanding the Active Plan window.

Shrinking the Active Plan Window

There shall be two shrink levels for the Active Plan Window. One shrink level sets the window to its minimum allowable size. The second shrink level sets the window to the last size set manually by the controller, which is almost certainly between the minimum allowable size and the full size.

Shrinking the Active Plan Window shall be accomplished by clicking on a "minimize" button located in the upper right corner of the window next to the "expand" button. Clicking on this button shall shrink the window to its minimum size. When the window is minimized this button shall be "grayed out" and clicking on it shall have no effect.

The controller shall also have a dedicated button on the toolbar that shrinks the Active Plan Window and allows the Provisional Plan Window to become visible. This button shall be in a fixed position on the left side of the tool bar.

Resizing the Active Plan Window

The controller shall also have the capability to resize the window by:

1. Placing the cursor on any edge of the window. The cursor shall change to a double-ended arrow.
2. When the cursor changes to a double-ended arrow press and hold the A-button on the trackball.
3. While holding the A-button depressed, shrink or expand the window by moving the trackball. *Note: size of the window will change, however the scale won't. The controller will likely need to change the scale so that a sufficiently large geographic region is displayed.*

Minimum Size of the Active Plan Window

The controller shall only be able to shrink the Active Plan Window to approximately 13% of the full area designated for map displays. (See paragraph 3.3.1.2.3 for the sizes of the window and the area designated for map displays.) This limit causes the Active Plan Window to always be available on the display, helping to insure that the controller remain aware of which plan (the active or provisional), they are working with or observing. Recognition of which plan is being used is an important part of maintaining situation awareness.

Changing the Scale of the Active Plan Window

The controller shall have the ability to change the scale of the Active Plan Window. Generic scale change options shall be limited to no more than five (5) discrete steps. Limiting scale changes to a relatively small number of discrete steps will allow the controllers to develop their skill at visually estimating distance better than if continuous scale adjustments were possible. The controller shall have the ability to over-ride the options and select a custom scale.

Selecting the scale from among the generic options shall be done by:

1. Clicking on the window header with the B-button on the trackball. This action shall cause a pop up window to appear
2. In the pop up window select the desired scale by clicking on the radio button in front of the desired option with the A-button on the trackball. When A-button is clicked, that scale value will automatically appear in the text field showing the scale.
3. If desired, the "save as default" option may be selected by clicking on that button.
4. Click on the "OK" button. The pop up window shall be removed from the display when the controller clicks on this button or on the "cancel" button.

Alternatively, the controller may select a custom scale by:

1. Clicking on the window header with the B-button on the trackball. This action shall cause a pop up window to appear
2. Placing the cursor in the text field in the pop up window and clicking on the A-button
3. Typing in a new value from the keyboard
4. Clicking on the OK button using the A-button
5. If the value entered is not within TBD limits, then an error message shall be displayed. This error message shall indicate that the value is outside the allowable range. The message shall also indicate the maximum and minimum allowable values. This error message shall have a button that returns the controller to the scale selection pop up window and another that allows the controller to cancel the process of selecting the scale.

The pop-up window used to set the scale is shown in Figure 3.3.1-3. *(Note: The scale values were created as examples. Input from the controller community will be required to identify the appropriate scales.)*

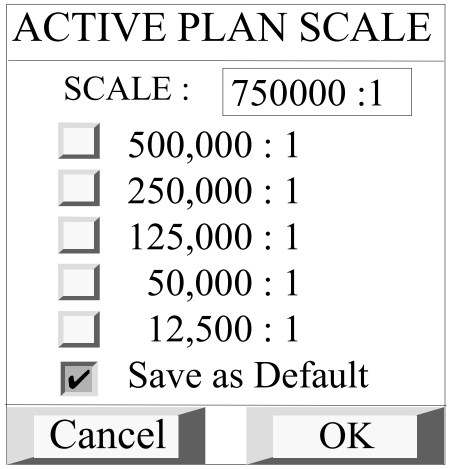

Figure 3.3.1-3. Pop-up window used to set the scale of the Active Plan Window. This example shows a controller-selected scale
(Note: The scale values were created as examples. Input from the controller community will be required to identify the appropriate scales.)

Highlighting

When the controller hooks an aircraft this window the aircraft shall be highlighted in this and all other windows. Similarly, if the controller hooks an aircraft in any other window that aircraft shall also be highlighted in this window.

<u>Provisional Plan Window</u>

Number of Provisional Plans

Each aircraft may have one, and only one, provisional plan. Controllers may make changes to the provisional plans of one or more aircraft in the provisional plan window.

Location of the Provisional Plan Window

The Provisional Plan Window shall appear to be behind the Active Plan Window, and shall be opaque. The Provisional Plan Window shall always occupy the entire area designated for map displays. The Provisional Plan Window may be completely occluded by, and will always be partially occluded by, the Active Plan Window. Tool windows may be placed over the Provisional Plan Window by the controller if they are transparent. (The capability to place tool and information windows over the radar display is currently in DSR. However, DSR currently allows these windows to be either opaque or transparent. [Controllers typically configure the windows to be transparent.] In EDA these windows must be transparent.)

Changing the Scale of the Provisional Plan Window

The controller shall have the ability to change the scale of the Provisional Plan Window. The methods used to change the scale shall be the same as those for changing the scale on the Active Plan Window.

Making the Provisional Plan Window Visible

The Provisional Plan Window may be entirely obscured by the Active Plan Window. In order for the controller to view the Provisional Plan Window, the Active Plan Window must be reduced in size. This is done by clicking on the minimize button located in the upper right hand corner of the Active Plan Window.

Highlighting

When the controller hooks an aircraft this window the aircraft shall be highlighted in this and all other windows. Similarly, if the controller hooks an aircraft in any other window that aircraft shall also be highlighted in this window.

Map Fast Action Button Area

This area contains two rows of buttons. The upper row contains button that allow the controller to edit the Active- or Provisional Plans of a selected aircraft. The second row of buttons controls the appearance of the display, turning display overlays on and off being an example.

Buttons Controlling the Provisional or Active Plans

The buttons in the first row allow the controller make inputs to selected aspects of the aircraft's trajectory or flight plan. It shall also contain a button that allows the controller to "share" a provisional plan with another controller. The minimum set of capabilities is defined in Section 3.2.1.1.

The controller uses these buttons to access flight parameters that are not accessed through the Flight Data Block (see Section 3.3.1.2.4 for a description of how changes are made through the Flight Data Block.) In order to make a change to the aircraft's active plan, the controller:

1. Hooks the aircraft in the Active Plan Window, the Active Conflict Window, or the STA or Active ETA columns of the Time Line Display.
2. Clicks on the desired button with the trackball's A- button. This will cause a pop-up menu to appear on the screen. This menu will contain the current value for the relevant parameter(s), or indicate the current option.
3. The controller edits the parameters or selects different options as desired.
4. The controller clicks either the OK button on the window to make the change to the Active Plan, or the CANCEL button to close the window without making a change.
5. If the controller clicked OK, then a pop-up window requiring the controller to confirm the intent to change the active plan shall appear. The controller may click OK to change the Active Plan, MODIFY PROVISIONAL PLAN to alter the Provisional Plan rather than the active Plan, or CANCEL to exit the process without making a change. (The rationale for allowing the controller to transfer the alterations to the Provisional Plan is that the controller may want to evaluate the change before making it active.)

The process of making a change to the Provisional Plan is similar, with two differences. The first difference is that to alter the Provisional Plan that the aircraft is hooked in the Provisional Plan Window, the Provisional Conflict Window, the Plan Acceptance Window, or the Provisional ETA column in the Time Line Display. The second difference is that there should not be a pop-up window requiring the controller to confirm the intent to modify the provisional plan. Note that the controller can make all of some of the changes to the Provisional Plan active through the Plan Acceptance Window.

Buttons Controlling the Appearance and Configuration of the Map Displays

The Map Fast Action Button Area also contains buttons that control the appearance to the Active and Provisional Plan Windows. The buttons in this area are those that the controller uses to toggle display features on and off. Controller input will be required to identify the set up functions that are performed so frequently, or have such high criticality, that they should be included in the Fast Action Button Area. Candidates include:

- Wind direction and velocity symbols
- Sector boundaries
- Military Operations Areas
- Restricted airspace

This area shall be located above the Message Window and extend across the screen.

The buttons in the Map Fast Action Button Area shall affect both the Active and Provisional Plan windows.

Active Conflict Window

The active conflict window shall always be displayed. This window shows a list of aircraft pairs from the Active Conflict List.

Order of Entries

The default order of presentation is by time to conflict in ascending order. The conflict that will occur soonest appears at the top of the list.

Sorting

The controller shall have the ability to sort the list in ascending or descending order using any single field in the list. To sort the list the controller "double clicks" with the trackball's A-button on a column heading. The list is then sorted in ascending (or alphabetical order if it is a text field). Double clicking on the column heading again sorts the list in descending (anti-alphabetical) order. This capability is intended to aid the controller in locating a conflict of interest.

Positive Indication of Absence of Conflicts

In the event there are no active conflicts, a positive indication of that fact shall be displayed in the window. A green rectangle located in the list area is recommended, as it will allow the controller to distinguish the indication from text on the dimensions of color and shape. The absence of information in this window is not a sufficient indication that there are no conflicts.

Highlighting

When the controller hooks an aircraft in this window the aircraft shall be highlighted in this and all other windows. Similarly, if the controller hooks an aircraft in any other window that aircraft shall also be highlighted in this window.

Position of the Active Conflict Window

This window shall always be displayed along the right side of the screen. The controller shall have the ability to shrink the window in height, but not in width.

Alerting the Controller of Conflicts

The EDA system shall alert the controller when a new active conflict is detected. This alert shall consist of a tone (TBD Frequency, TDB duration) accompanied by a flashing of the Active Conflict Window header area. The header area shall flash for approximately 2 seconds at a 2 Hz rate, with equal proportions of time in the off and on states.

Provisional Conflict Window

This window shows a list of aircraft pairs from the Provisional Conflict List. The provisional conflict window shall always remain on the screen. It shall always be on the right side of the screen. It may be reduced in height but not in width by the controller.

If there are no provisional conflicts, a positive indication shall be presented (e.g., a green rectangle located in the list area). The absence of items in the list is inadequate.

It is expected that this list will change often as the controller evaluates provisional plans. That is, as the controller makes a Provisional Plan for a particular aircraft the list will expand when the provisional plan adds a new conflict. The list will shrink when the Provisional Plan eliminates a conflict with another provisional or active plan.

Highlighting

When the controller hooks an aircraft this window the aircraft shall be highlighted in this and all other windows. Similarly, if the controller hooks an aircraft in any other window that aircraft shall also be highlighted in this window.

Sequence List

Figure 3.3.1-4 shows the sequence list. The sequence list contains information related to the flow conformance of all aircraft, “owned” and “unowned” in each metering stream (e.g., for each metering fix). This information includes the aircraft ID, the length of time the aircraft’s ETA using the active plan is ahead of or behind the STA (active delay), the amount of time the aircraft’s ETA using the provisional plan (if there is a provisional plan) is ahead of or behind the STA (provisional delay), the speed and heading of the aircraft, the aircraft type, and the ETAs based on the active and provisional plans. Other data contained in existing metering list would also be included in this window.

SEQUENCE

ACID	ACTIVE Delay	PROVS. Delay	SPEED	TYPE	STA	ACTIVE ETA	PROVIS. ETA
AAL1234	(4:00)	(1:30)	270	B727	23:29:00	23:25:00	23:27:30
US8765	1:25	0:00	260	AB330	23:30:15	23:31:15	23:30:15
SWA1029	(3:10)	0:45	280	MD80	23:31:30	23:28:20	23:32:15
TWA567	0		260/	B757	23:32:45	23:32:45	

Figure 3.3.1-4. Sequence List

The sequence list is being made available in addition to the time line display, which is a more graphical representation of flow conformance. The sequence list is being made available principally to ease the transition of experienced controllers to the new GUI.

Ordering of Columns

Figure 3.3.1-4 shows an acceptable ordering of columns for initial use. However, insufficient information has been identified to define the optimum ordering of the columns to support the controllers.

In order to provide flexibility in the ordering of columns, controllers shall have the ability to reorder the columns in this table, with the exception of the ACID column, which shall always remain on the left edge of the window. Reordering the columns shall be accomplished by:

1. Placing the cursor over the column heading
2. Pressing and holding the B-Button on the trackball
3. Sliding the column left or right to the desired position
4. Releasing the B-Button when the column is in the desired position.

The controller shall also have the ability to reorder the columns using a system configuration menu. This menu shall be accessed by clicking on the system configuration tab on the tool bar and then selecting Scroll Bar Set Up. The Scroll Bar Set Up menu shall have a list of all columns, and the controller shall be able to hook a column name and drag it so that it is in the desired sequence relative to the other columns. This menu shall allow the controller to save this sequence as a default.

Sorting

The controller shall have the ability to sort the sequence list using data in any of the columns. Sorting shall be accomplished by placing the cursor over any of the column headings and double clicking the A-button on the trackball. The data in the list will then be sorted into ascending order using the data in that column. Double clicking on the same column a second time will reverse the order so that the data is in descending order

Scrolling

The controller shall have the ability to scroll through the sequence list. Scrolling can be done either by using the slider tool located to the right side of this window, or by using the up and down arrow keys on the keyboard once an entry in the table has been hooked.

A horizontal scroll bar allows the controller to scan data fields to the left or right of those displayed in the window. It is expected that input from the user community will be needed to identify the best order for these variables. The ACID column shall always remain on the left edge of the window and shall not be moved by horizontal scrolling.

Minimizing the Sequence List

The sequence list is an optional window. The controller shall have the capability to remove the window from the display. The controller shall be able to click on a “minimize” button. This button shall be located in the upper right hand portion of this window. When the controller clicks the trackball’s A-button on this button, the window shall be removed from the screen. When the window is minimized using this method, an icon shall be displayed on the tool bar. Double clicking on this icon shall restore the sequence list to the display.

Display of the sequence list can be configured to suit the controller's preference. This preference is made using a System Configuration menu. The System Configuration menu is accessed through a button on the tool bar. When the option for the sequence list is selected, then the list will be displayed (or "iconized" if the controller has minimized the window).

Highlighting

When the controller hooks an aircraft in this window the aircraft shall be highlighted in this and all other windows. Similarly, if the controller hooks an aircraft in any other window that aircraft shall also be highlighted in this window.

Plan Acceptance Window

The plan acceptance window provides the controller a means to accept all or parts of the provisional plan for each "owned" aircraft having a provisional plan, or to accept all of the provisional plans for all aircraft having provisional plans.

Location on the Display

The Plan Acceptance Window shall remain on the screen. The Plan Acceptance Window shall always be on the right side of the screen.

Resizing the Plan Acceptance Window

The Plan Acceptance Window may be shrunk in height, but not in width by the controller.

Adding Provisional Plans Into the Plan Acceptance Window

When a provisional plan is created for an aircraft that is "owned" by the controller, by the EDA system using automatic or semi-automatic modes the Plan Acceptance Window shall automatically reflect the existence of that plan.

If a provisional plan is generated by a source that does not "own" the aircraft, e.g., another controller, the flight deck crew, then the controller who "owns" the aircraft shall have the capability to allow the plan created by others to become the provisional plan. Once the second party created plan is made provisional by the controller who "owns" the aircraft it is treated as any other provisional plan. (That is, it may be made active, modified, or "un-done" by the controller who "owns" the aircraft.)

Control Over Making the Provisional Plan Active

The provisional plan may be "accepted" (or "promoted") so that it becomes the active plan for that aircraft only by the controller who "owns" the aircraft. The controller shall have the capability to "accept" all, or parts of a provisional plan for a single aircraft, as well as to "accept" all of the provisional plans that exist for "owned" aircraft.

Once all of a provisional plan is made active that aircraft will no longer have a provisional plan. (This does not limit the ability of the controller, another controller who does not "own" the aircraft, or the aircraft to generate a new provisional plan after a provisional plan has been accepted.) However, the aircraft may still have an active or a provisional conflict or have a metering issue.

Figure 3.3.1-5 shows the Plan Acceptance Window. Any aircraft having a Provisional Plan created by the controller who "owns" that aircraft, or a Provisional Plan created by another party granted sharing by the “owning” controller, has an entry in this window. If the provisional plan for an aircraft differs from the active plan in only one degree of freedom (DOF) then a button will be displayed only for that degree of freedom. AC321 in this figure is an example. Similarly, if the provisional and active plans differ in two DOF then there will be two buttons for that aircraft in this window.

Note that the Delay column in this window shall contain the delay remaining should the provisional plan be “accepted”. This provides the controller information that can be used to asses the effectiveness of the provisional plan.

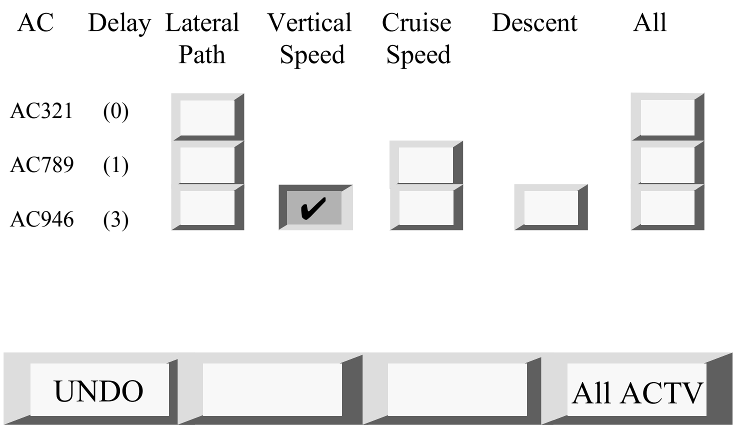

Figure 3.3.1-5. Plan Acceptance Window. This window allows the controller to make any or all aspects of the provisional plan active for any aircraft having a provisional plan (This figure shows the window as the controller selects the vertical speed component of the provisional plan for flight AC946 to be made active.)

In order to “accept” a single DOF for a particular aircraft the controller shall:

1. Place the cursor over the desired button. The cursor shall change from an arrow to a cross when it is over a button.
2. Click on the A-button on the track ball. When the A-button is clicked the button will appear to be depressed (see, for example, the vertical speed DOF button for AC946 in Figure 3.3.1-3).
3. The button for the DOF that has been accepted shall stay in the depressed position the greater of 0.5 seconds or until the EDA system has made that DOF of the provisional plan active. This provides visual feedback to the controller regarding the DOF that was “accepted”.
4. Select other DOFs to be accepted. (This step is optional.)
5. Click on the ALL button for that aircraft. When this is done the DOFs selected will be made a part of the aircraft’s Active Plan and those buttons will be removed from the Plan Acceptance Window. If there are no DOFs having provisional plans for that aircraft, the aircraft shall be removed from the Plan Acceptance Window until a new Provisional Plan is created for that aircraft.

Controllers shall also have the capability to accept all DOF of the provisional plan for a single aircraft with a single action. This is accomplished by having the controller place the cursor over the button in the “ALL” column on the right side of the window in the row for the desired aircraft, and clicking the A-button on the mouse. As in the case of a single DOF, the button shall appear to be depressed when it is clicked, and remain in that state until either 0.5 second has past or until the provisional plan is made active. Once the entire provisional plan for an aircraft is made active, that aircraft no longer has a provisional plan and will be removed from the Plan Acceptance Window.

Finally, controllers shall have the capability to accept the entire set of provisional plans for all DOF and all aircraft with a single action. Here the action is simply to click on the "ALL ACTIVE" button in the lower right hand portion of the Plan Acceptance Window. As with other buttons, it shall appear depressed a minimum of 0.5 sec or until the provisional plans are all active. Again, when all of the provisional plans are made active, there are no provisional plans for any aircraft and the list is cleared.

"UNDO" Function

The controller shall have the ability to "UNDO" a provisional plan and restore the previous provisional plan for that aircraft. The "Undo" feature shall function regardless of whether the provisional plan was created by the controller who "owns" the aircraft, another controller who does not "own" the aircraft, or by the flight crew aboard the aircraft.

The "UNDO" function is activated by hooking an aircraft in the Plan Acceptance Window or in the Provisional Plan Window and then clicking on the "UNDO" button in the Plan Acceptance Window.

If the aircraft did not have a Provisional Plan that was superseded by the current Provisional Plan then clicking on the "UNDO" button shall be grayed out. The "UNDO" function shall not restore a previous Provisional Plan if that plan had been made active by the controller.

Sharing of Provisional Plans

Normally, provisional plans are displayed only on the workstation of the controller who "owns" the aircraft. However, there are situations where a provisional plan is made available to a controller who does not "own" the aircraft, or made available to an aircraft. This is being called "sharing". The process of sharing a Provisional Plan is described in Section 3.3.1.2.4.

Highlighting

When the controller hooks an aircraft in this window the aircraft shall be highlighted in this and all other windows. Similarly, if the controller hooks an aircraft in any other window that aircraft shall also be highlighted in this window.

<u>Message Window</u>

The message window is a general-purpose area where information can be displayed. Information that can appear in this region of the display includes:

- Data linked messages
- Flight plan intent information (e.g., Flight Data Strips)

<u>Toolbar</u>

This area contains Fast Action Buttons (FAB) and tabs that bring up menus containing other tools and controls. Controls that are frequently used by the controllers or are time critical (e.g., expand the active window to full size to support the situational awareness of the controller) shall be implemented as FABs. When the controller clicks on a FAB, a single function shall be performed. Each function may consist of a number of steps, however this shall be transparent to the controller.

Tabs that bring up menus of tools and/or controls are used for controls that are neither time critical nor used frequently. For example, one tab may bring up a menu of system configuration options, such as the set up of the trackball, or a menu to tailor the flight data block.

Tool and control windows that are brought up by the tabs on the toolbar will appear in the message window. These windows shall be semi-transparent, allowing the information beneath them to be viewed. The controller shall have the capability to drag these windows to other positions on the screen, and to minimize the window so that it can be restored to the display rapidly. When the controller restores a window that has been minimized, the window shall appear in the position it occupied when it was minimized.

<u>3.3.1.2.4</u> <u>Specific Tasks</u>

Creation of Provisional Plans

<u>Adding Provisional Plans to the Plan Acceptance Window</u>

When a provisional plan is created for an aircraft, regardless of whether it is created by the EDA system, manually by the controller who "owns" the aircraft, by another controller, or by the aircrew, it shall be added automatically to the Plan Acceptance window. If the aircraft already has a provisional plan, the new provisional plan shall replace the old one on a DOF by DOF basis. In other words, if both the new and old provisional plans contain cruise airspeeds, the new value would replace the old value. If the existing provisional plan did not manipulate cruise airspeed then the new value would be added to the other DOFs in the provisional plan.

The default order of the list in the Plan Acceptance Window shall be alphabetical. The controller shall have the capability to sort the list by clicking on any of the column headers.

<u>Manual Creation of Provisional Plans - Speed, Altitude, and Vertical Speed</u>

Making Changes in the Provisional Plan Window

Note: The process for altering air and ground speeds, altitude, and vertical speed is identical. Only the values in the menu used to select the desired value differ.

1. Place the cursor over the desired field in the Flight Data Block (FDB) for that aircraft in the Provisional Plan Window. The field will be highlighted and the cursor will change from an arrow to a cross when the cursor is over an editable field.
2. Click on the trackball's A-button. This will open a menu containing values that may be selected by the controller. An example of a window for aircraft altitude (flight level) selection is shown in Figure 3.3.1-6.
3. If the desired value is present in the menu, place the cursor over the value and click the trackball's A-button. The selected value will be highlighted and moved to the middle of the window.
4. If the desired value is not in the window, the controller may use the slider bar or arrows on the right side of the menu to scroll the values until the desired value appears and then select it as described in step 3, above. Alternatively, the controller may place the cursor in the digital read out box, click the A-button on the trackball and then type in the desired value on the keyboard.
5. After the desired value has been selected, the selection is accepted by placing the cursor over the ACCEPT button and then clicking the A-button on the trackball.

6. If the controller desires to exit without making any changes, the cursor is placed over the CANCEL button and the trackball's A- button clicked.

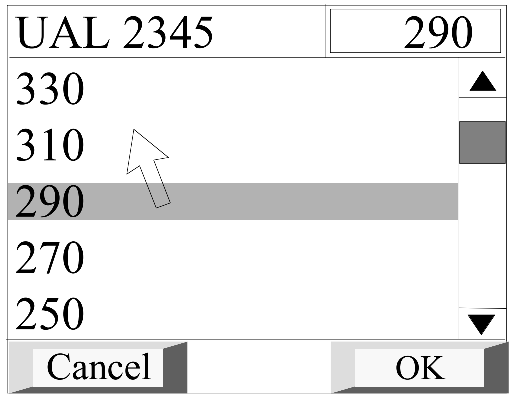

Figure 3.3.1-6. Tool used to select aircraft altitude. Tools used to set the aircraft's speed and vertical speed are similar

Making Changes in the Message Window

The controller can bring up current provisional plan information in the Message window by

1. Either dwelling on the aircraft symbol or FBD block in the Provisional Plan Window, or by clicking on the B-button when the cursor is on the aircraft. (If the aircraft does not have a provisional plan, the active plan information is displayed in the Message Window.)
2. Select a field to edit in the provisional plan by clicking on that field using the trackball's A-button. Once a field is edited, UPDATE and CANCEL buttons will be displayed adjacent to the aircraft's identifier. These buttons will allow the controller to make the changes part of the Provisional Plan by updating the field or fields that have been edited, or to cancel the editing process without making any changes to the existing plan, respectively
3. Once a field is selected, the controller can edit the values from the keyboard, or can "cut and paste" values into the field from other Provisional- or Active Plans.
4. Clicking on the UPDATE button
5. The controller may exit the plan-editing mode by clicking on the CANCEL button.

Manual Creation of Provisional Plans – Route Changes

The controller shall have the capability to alter the track of the aircraft in the provisional plan by either clicking and dragging points on the aircraft's planned route to create a new provisional route, or by editing the Provisional Plan in the Message Window.

When the route is stretched the ETA of the provisional plan shall be adjusted on the Time Line Window and on the Metering List when the controller makes route changes by dragging the course in the Provisional Plan Window. When the controller edits the route in the message window, the provisional ETA shall be updated only when the UPDATE button is clicked.

The Controller shall also have a library of commonly used path stretch patterns (e.g., s-turn). These patterns may be copied from the library and inserted into the provisional plan of an aircraft. This library may include templates that are tailored to the characteristics and standard operating procedures of a particular sector. (For example, there could be an asymmetrical holding pattern in an area where terrain considerations rule out a conventional "race track" pattern.) These patterns may be repositioned along the aircraft's route, and the controller may stretch the patterns. This set of path stretch patterns is made visible by clicking on a PATH STRETCH button in the Map Fast Action Button area. Clicking this button will cause a pop-up window to appear. This window will contain templates for various path stretch maneuvers including:

- S-turns going left and then right of a path
- S-turns going right and then left of a path
- Turns going to the left of a path and then returning to the path
- Turns going to the right of a path and then returning to the path
- Holding patterns
- Other commonly used patterns are TBD

The Path Stretch Tool is shown in Figure 3.3.1-7.

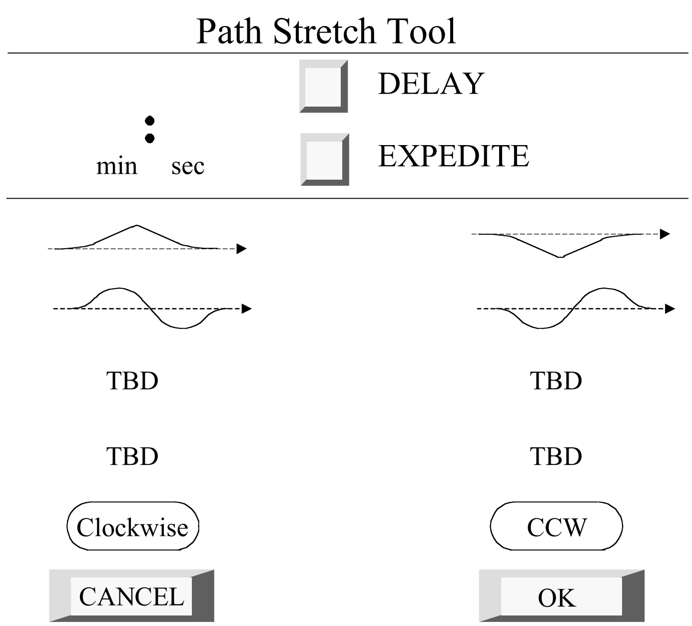

Figure 3.3.1-7. Path stretch tool

The controller can select one pattern by placing the cursor over the pattern, pressing and holding the trackball's A-button, and dragging the pattern to the desired location on the aircraft's route. The pattern will then be inserted into the aircraft's route. The controller can drag the pattern to "fine tune" the delay if desired.

Creation of Provisional Plans Other than by the Controller Who "Owns" the aircraft

The controller who "owns" an aircraft shall have the capability to allow another controller (who does not "own" that aircraft) to prepare a Provisional Plan.[23] This would be done, for example, when two controllers are cooperatively resolving a conflict or scheduling problem, of by a flight crew during trajectory negotiation. The process of creating a provisional plan is the same as for creating a provisional plan for an "owned" aircraft. However, only the controller who "owns" the aircraft can make the provisional plan active, regardless of who created the provisional plan.

[23] The current approach within the GUI design is to not allow provisional plans to be developed by controllers other than the "owning" controller unless approval is given. It is anticipated that this approach may change.

In order to allow a controller who does not "own" the aircraft to create a provisional plan, the controller who "owns" the aircraft must grant that authority. This is done by placing the cursor over the aircraft and then clicking on the trackball's C-button. This will open a window where the controller who owns the aircraft can select the controller being granted authority to prepare a Provisional Plan for that aircraft. This window is closed either by clicking on either the OK button or the CANCEL Button. Once one of these buttons is pressed, the window is removed from the display.

If authority to create a Provisional Plan is delegated, the Provisional Plan created by the controller who does not "own" the aircraft appears on both controller's displays and in both their Provisional Conflict Lists.

Authority to make the Provisional Plan active remains with the controller who "owns" the aircraft and cannot be delegated.

Provisional plans for "owned" aircraft that are prepared by controllers who do not "own" the aircraft are shown on the provisional plan windows of both the controller who "owns" the aircraft and the controller with whom the plan is shared. For example, in the case of controllers cooperatively addressing a conflict, another controller may create a provisional plan for an "un-owned" aircraft and "share" it with the sector controller who does "own" the aircraft. The "owner" of the aircraft may then "accept" the provisional plan developed by the other controller, or take other action as appropriate (e.g., make an alternative provisional plan to that proposed by the other controller).

Provisional plans generated by "owned" aircraft are also displayed on the provisional plan window as a part of the trajectory negotiation process. In this case an aircraft would prepare a provisional plan indicating the preferred trajectory as a provisional plan and send it to the controller who "owns" the aircraft. The controller would have the option to approve and send the plan back to the aircraft, to modify the trajectory proposed by the aircraft, or to create a new trajectory. In each case, the controller would send the plan back to the aircraft via data link. Once the plan was entered into the aircraft's FMS it would be considered the active plan.

<u>Making a Provisional Plan Data Linked Up to an Aircraft Active</u>

Controllers may also send a provisional plan via data link to an aircraft that they "own". In this case, the provisional plan would be "accepted" (i.e., made active) when the receiving aircraft indicates that the plan will be followed. (The mechanism for indicating that a plan has been received and will be followed by the aircraft has not been determined at this time. However, for the present purpose it is sufficient to assume that the aircraft will data link a confirmation that the plan was received and entered into the FMS to the controller's workstation. When that confirmation is received at the workstation, the plan will be considered active.)

Automation of Provisional Plan Creation

<u>Selection of Advisory Generation Mode</u>

Controllers shall be able to select between the two modes, automatic and semi-automatic, of advisory generation for both metering and conflict resolution. To select the Advisory Generation mode the controller brings up the pop-up menu used to select these modes by clicking on a button on the Tool Bar. The controller selects the desired mode for metering and for conflict resolution. (The mode selected for metering does not have to be the same as that for conflict resolution.) The controller shall have the ability to save these selections as defaults by clicking on the SAVE AS DEFAULT button. One the controller has finished making their selection, they click on the OK button to cause the elections to take effect or they click on the CANCEL button to close the window without any of their choices taking effect. The pop-up menu for making this selection is shown in Figure 3.3.1-8

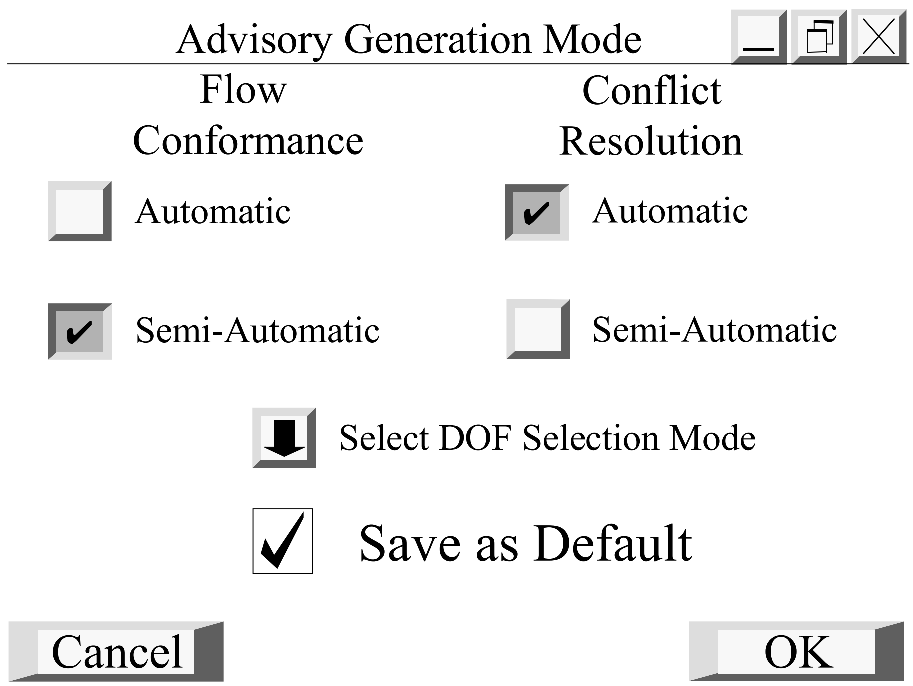

Figure 3.3.1-8. Advisory Generation Pop-up Menu

Before closing this pop-up window, the controller may specify the DOF selection mode for metering and for conflict resolution

<u>Selection of degrees of freedom (DOF) for Advisory Generation</u>

The controller can select the system's operating mode for advisory generation. There are three modes available: Manual, Controller-defined, and EDA-defined (see Section 3.2.2.3.1 for a definition of the modes for metering conformance and Section 3.2.4.2.2. for a definition of the modes for conflict resolution.)

The controller accesses the tool to select the modes by clicking on the MODE SELECTION button on the Advisory Generation Pop-up menu. This causes another pop-up menu to appear. The second menu is shown in Figure 3.3.1-9.

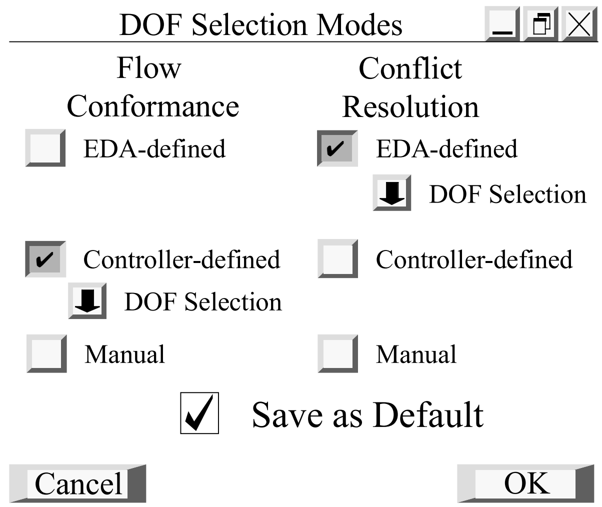

Figure 3.3.1-9 Degree of Freedom Selection Mode Pop-up Window

In the DOF Selection mode window, the controller clicks on the desired modes for flow conformance and conflict resolution. These buttons are displayed only for the selected option. In Figure 3.3.1-9, the buttons for Controller-defined DOF selection mode for flow conformance, and for EDA-defined DOF selection mode for conflict resolution have been selected. As the DOF selection mode is not applicable in the manual selection modes, arrows will not be displayed if MANUAL is selected.

The controller may click on the SAVE AS DEFAULT button to save these selections as the default.

The controller may click on the CANCEL button to exit to the previous menu without having the selections take effect, or may click on the OK button to use those selections.

<u>Specification of the DOFs available</u>

After picking a DOF Selection Mode, the controller specifies the DOFs to be used. Clicking on the DOF SELECTION button spawns a third pop-up window. This window allows the controller to specify either a specific (Controller-defined) DOF mode or the DOFs that the system will have available (EDA-defined). See Sections 3.2.2.3.1 and 3.2.4.2.2 for more details on possible selections. Figure 3.3.1-10 shows an example of the window for Controller-Defined Flow Conformance. Note that each of the windows at this level will contain different entries as the DOFs available are not the same in all cases.

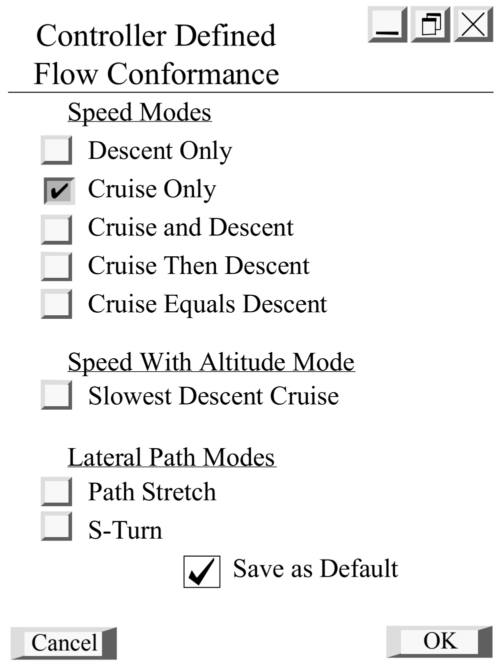

Figure 3.3.1-10 Pop-up window for selection of the degrees of freedom used in Controller Defined Flow Conformance

To select a DOF for use, the controller clicks on the button in front of the desired option or options. When the controller has finished selection the options, they may make those selections the default by clicking on the SAVE AS DEFAULT button. Clicking on the OK button makes the selected DOFs available to that mode of EDA, while clicking on the CANCEL button exits without any of the selections taking force. Clicking on the CANCEL or OK button closes this menu and returns the controller to the previous menu.

3.3.1.2.5 General GUI Design

This section describes a variety of features. Some, if not many, of these capabilities may already have been implemented in the operating system, although the details may differ. The methods of implementing the capabilities described here are intended for use when the equivalent capability does not already exist.

In many cases, the exact implementation is not as important as the consistency of the interface. For example, there is likely to be little performance difference between windows where the controls (expand and minimize buttons) are located to the left or right side of the title bar. However, there would be a performance decrement if the location of the controls were not consistent. If a technique (or widget) already exists to accomplish a task, that technique should be considered for use. The key is to provide the user with tools that are located in a consistent location and operate is a consistent manner throughout the system.

"Hooking" An Aircraft

Hooking in the Active or Provisional Plan Windows

Aircraft can be hooked in either the active or provisional plan windows. If an aircraft is hooked in the active window, it shall be highlighted in the provisional plan window and vice versa. It shall also be highlighted in the other windows. This highlighting aids the controller in locating that aircraft and the data needed to make clearance decisions.

1. Place the cursor over the aircraft symbol or over the Flight Data Block (FDB) other than over the speed, altitude, or vertical speed readout areas of the FDB. (The flight number is an area that can be "hooked" without any risk of changing other fields.) When the cursor is over an area that can be "hooked", it will change from and arrow to a cross
2. Click the A-button on the trackball. The aircraft symbol and the FDB will be highlighted on the display. In addition, aircraft in conflict with the hooked aircraft will be highlighted and a line connecting the aircraft in conflict will be drawn. Active and provisional conflicts involving the hooked aircraft, if any, will be highlighted in the relevant conflict list. The conflict list will scroll, if necessary, so that the conflict involving the hooked aircraft that will occur first is visible in the window.
3. The aircraft can be "un-hooked" by moving the cursor to an unoccupied area of the radar display and clicking the A-button on the trackball.

<u>Hooking an Aircraft in a List</u>

An aircraft can be hooked in any of the lists in which it appears (i.e., the Active Conflict Window, the Provisional Conflict Window, the Plan Acceptance Window, and the Time Line Window). Hooking is done by clicking the A-button on the trackball when the cursor is over the flight number.

When an aircraft is hooked in a list, it shall be highlighted in the other windows.

<u>Hooking Multiple Aircraft</u>

The controller shall have the capability to have multiple aircraft hooked simultaneously. This capability might be used, as an example, if the controller wished to have EDA automatically generate delay absorption plans for all of the aircraft using a specific degree of freedom. In order to hook multiple aircraft, the controller:

1. Hooks the first aircraft using any hooking method.
2. Presses and holds the shift key down
3. Hooks the second (and subsequent) aircraft

An aircraft may be removed from a set of hooked aircraft by clicking on that aircraft while holding the shift key depressed. An aircraft can be added to the set by depressing the shift key and clicking on the aircraft.

When all of the desired aircraft are hooked, the controller shall release the shift key and proceed to perform the task using the collection of hooked aircraft. The aircraft shall remain hooked until the controller performs an action to unhook. (The action to unhook is clicking on a blank region of the display, or hooking a single aircraft).

<u>Highlighting A Hooked Aircraft</u>

When an aircraft is hooked, it shall be highlighted by the system. This confirms to the controller that the system has recognized the action made by the controller. Highlighting shall be done using redundant dimensions in order to make the change conspicuous to the controller. A hooked item shall be increased in size and brightened.

Changing Text And Background Colors In A Window

There are two ways to access menus for changing the colors of text and background in a window. The first method is through the window itself. The second method is through the System Setup menu.

From the window:

1. Place the cursor in the header area of the desired window
2. Click trackball's B-button. A pull down menu will appear
3. Move the cursor into the pull down menu
4. Place the cursor over the button in front of the desired background (font) color
5. Click the trackball's A-button to select the color. The button will change from the OFF position to the ON position.
6. Place the cursor over the button in front of the desired font (background) color
7. Click trackball button A to select the color. The button will change from the OFF position to the ON position.
8. If you desire the colors to become the default colors for that window place the cursor in the box labeled "Save as Default" and click trackball button A. A check will appear in the box. If you do not want the colors to become the default skip this step.
9. Move the cursor onto the OK button and click trackball button A. The colors will change in the window and the color selection menu will be removed from the screen.
10. If you do not want to make this color change, move the cursor onto the CANCEL button and then click trackball button A. The menu will be removed from the screen and the colors will remain unchanged.

From the System Setup Button:

1. Click in the window of interest to select it.
2. Click on the System Configuration button on the Tool Bar.
3. Select the Set Color option
4. Select the desired colors
5. Click OK to accept the new choices, or click CANCEL to close the menu without making any changes.

Moving A Flight Data Block (FDB)

1. Place the cursor over the aircraft identifier (flight number) in the flight data block (FDB). The cursor will change from an arrow to a cross
2. Press and hold the A-button on the trackball. The entire FDB will be highlighted when it can be moved.
3. Using the trackball slide the FDB vertically and/or laterally to the desired position. Once in the desired position release the trackball's button. (Note: As the FDB is moved a line will be drawn from the aircraft symbol to the FDB.) Releasing the button will remove the highlighting from the FDB.

Setting the Length Of Time Probed

Setting the length of time probed is an instance where the setting is made in discrete units, rather than continuously. The tool used differs somewhat from a general slider tool because the smallest increment is minutes. The tool for setting the length of time probed is shown in Figure 3.3.1-8.

1. The length of time probed may be set by (a) placing the cursor over the slide bar, pressing and holding trackball button A, and sliding the trackball left or right, and releasing the trackball button when the desired setting is attained, or (b) by placing the cursor over the arrow at either end of the slider and clicking the A trackball button to increment or decrement the value, or (c) by placing the cursor into the text field, clicking trackball button A, and then typing the desired value from the keyboard.
2. If either method (a) or (b) are used, the bar will jump in 1-minute intervals. The digital readout will also change in 1-minute intervals as the slider bar is moved.

3. If method (c) is used, the slider bar will be positioned to show the value currently entered into the digital readout box. (e.g., if the controller has entered a “9”, then the slider will be positioned so that its end is at the 9 minute position. If a value greater than the maximum is entered, the value shall be the maximum allowable.)

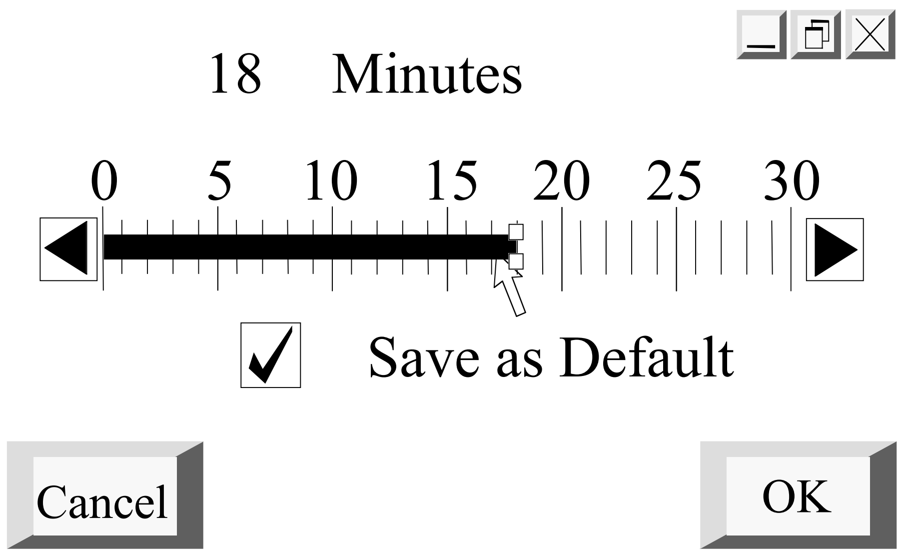

Figure 3.3.1-8. Tool used to set the length of time that is to be conflict probed

Path Stretching To Absorb Delays

<u>Aided Path Stretching</u>

The path stretch menu is brought up by clicking on the Path Stretch button in the tool bar.

1. If one aircraft is already hooked, then the identifier for that aircraft shall be automatically entered into the ACID field in the menu. (The controller may type in the ACID of another aircraft, or may replace the existing ACID by hooking another aircraft.) If no aircraft is currently hooked then either type the flight identifier into the ACID field or hook the flight in the provisional plan window.
2. Select the type of path to be used (e.g., S-turn, deviate to the pilot’s left or right of the current flight path) by clicking on the desired option.
3. Enter the amount of delay to be absorbed or the amount of time to be gained. The format shall be MM:SS. If the controller enters only two digits they shall be considered seconds. If the controller enters three digits, e.g., “123”, then the first digit, e.g., “1”, shall be considered the number of minutes and the second and third digits, e.g., “23”, shall be considered seconds.
4. Aircraft for which a new route is desired by placing the cursor on the aircraft symbol or Flight Data Block and clicking the A-button on the trackball. (If the cursor is on the FDB, it must be in a location that is not one of the fields that can be selected for editing [i.e., speed, altitude, or vertical speed]. The flight number [e.g., AA1234] is one such area in the FDB.)

Once the desired route stretch has been selected the system’s recommended route will appear in the Provisional Plan Window. In addition, the aircraft will be listed in the Plan Acceptance

Window (located on the right side of the display) along with buttons allowing the controller to make this and any other aspects of the Provisional Plan active.

Manual Path Stretching

1. In the Provisional Plan "God's Eye View" window, identify the line representing the route of the aircraft that is to be stretched.
2. Place the cursor on the route at the point on the route you want to move. Press and hold the A-button on the trackball and drag the point to a new location. As the point is dragged, the amount of delay to be absorbed will be updated in the Provisional Plan Tool window. Release the button when the point on the path is in the desired position.
3. Repeat step 2, above, as desired to create a suitable path.
4. When the path is satisfactory, it can be made active by pressing the LATERAL button in the Provisional Plan Tool Window. Pressing the ALL button will make the provisional lateral plan active as well as speed or vertical speed provisional plans for that aircraft.

General GUI Information and Definitions

The following sections describe capabilities that are commonly included in many systems, and may exist in the EDA system. This section is included to (a) identify the capabilities required in this GUI design, (b) to provide guidance if the capabilities do not exist, and (c) to provide guidance in modifying existing capabilities to be consistent with this GUI.

If these capabilities exist, but in a slightly different form (e.g., the buttons on windows are located in different locations, the labels are different) or use different conventions, consideration should be given to the possibility of using the existing interface rather than to develop new software.

Response Latency of the System to Controller Inputs

The controller shall receive rapid and consistent feedback that an input has been recognized by the EDA system. An initial response to user input should take priority over any other activity at the interface, and should be provided in 125 msec or less. As an example, when the controller clicks on a field in the flight data block, the system should display the relevant pop up menu within 125 msec.

If the system requires time in excess of 125 msec to perform a task, then the controller shall be given an indication that the system has recognized an input has been made and is working on the request. This may be implemented as a clock face symbol or an hourglass, or other symbol commonly used to indicate that the system is working. It is desirable that the symbol be dynamic so that the controller can determine if the system has "hung". For example, moving clock hands would indicate that the system is working. Stationary clock hands would indicate that the system has "hung" or "frozen".

Cursor Controller

Definitions

The trackball buttons are labeled A, B, and C. These are shown for a right-handed trackball, which is the default, and for a left-handed trackball in Figure 3.3.1-9. The labeling of the buttons will be the same for a mouse; Button A is on the left, Button B is in the middle, and Button C is on the right for a right handed mouse, and the positions reversed for a left handed mouse.

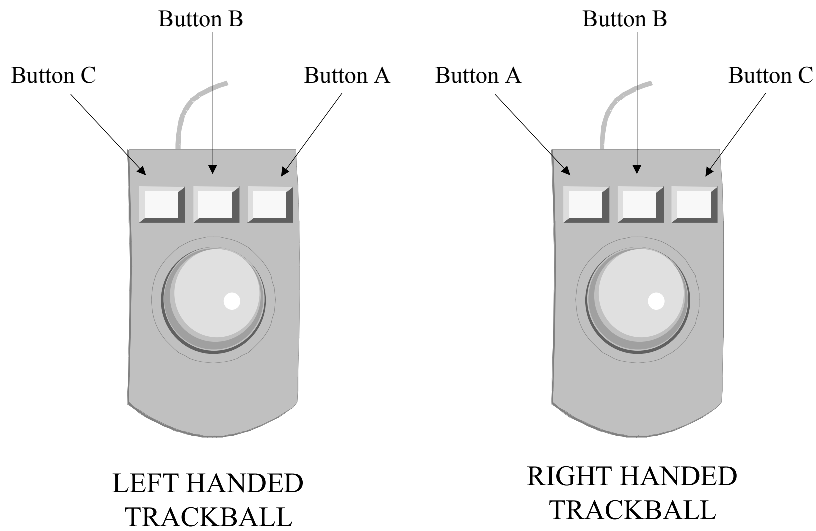

**Figure 3.3.1-9. Cursor Controller Button definitions. This figure shows the labeling of buttons on right and left-handed trackballs
Extension of the button assignment to a mouse is straightforward.**

Setting up the Cursor Controller

This menu allows the controller to configure the buttons on the cursor controller for right- or left-handed operation, the time between successive button presses that distinguishes between a "double-click" and two separate clicks, and to adjust the relationship between movement of the track ball or mouse and the movement of the cursor on the display. These options are common in most COTS operating systems.

Opening and Closing the Cursor Controller Set Up Menu

The Cursor Control Set Up menu shall be accessed by clicking on the button on the tool bar. This menu shall be closed by either clicking on the "X" icon in the upper right portion of the window, or by clicking on the "OK" button in the lower right portion of the menu.

Selecting A Right- Or Left-Handed Cursor Controller

This allows the controller to configure the track ball for use with either the left or right hand. When configured for right-handed operation, Button A is located on the left side of the device. In this case, button A can be pressed with the index finger of the controller's right hand. When configured for left handed operation, Button A is located on the right side of the device. When in left-handed configuration, Button A can be pressed with the index finger of the controller's left hand.

1. Place the cursor over either the RIGHT HANDED or LEFT HANDED buttons as desired. (A right-handed controller is the default).
2. Click on button A.
3. Visually verify that the desired option has been selected. The button indicating the selected option will appear to be pressed.

Setting The Double Click Speed

This setting is used to adjust the time between successive button clicks used by the system to distinguish between a "double click" and two separate button presses.

1. The speed of double clicking the trackball's buttons is set by (a) placing the cursor over the slide bar in the CLICK SPEED portion of the window, pressing and holding the trackball's A-button and sliding the trackball left or right, and releasing the trackball button when the desired setting is attained, or (b) by placing the cursor over the arrow at either end of the slider and clicking the A-button on the trackball to increment or decrement the value, or (c) by placing the cursor into the text field, clicking the A-button on the trackball, and then typing the desired value from the keyboard.
2. The trackball can be tested by placing the cursor in the region to the right side of the panel and double clicking any of the trackball buttons. When the system determines that a double click has been detected the test area changes color.

Selecting the Acceleration Value

The acceleration value is used to set the non-linear relationship between the velocity that the controller is moved and the distance that the cursor moves on the screen. At one end of the scale, the velocity of the controller has no effect on the magnitude of the motion of the cursor on the screen; the motion of the cursor is only related to the distance that the cursor controller is moved. At the other end of the scale, the cursor moves a greater distance for a given magnitude of controller movement when the controller movement is rapid than when it is slow. Three methods available to make this adjustment are described below.

Method 1

1. Place the cursor over the slide bar in the ACCELERATION portion of the window
2. Press and hold Button A
3. While Button A is depressed slide the controller left or right.
4. When the desired setting is reached, release the trackball button.

Method 2

1. Place the cursor over the arrow at either end of the slider
2. Click the A-button on the trackball to increment or decrement the value

Method 3

1. Place the cursor into the text field
2. Click trackball's A-button to make the field active
3. Type the desired value from the keyboard.

Selecting The Gain

This setting adjusts the gain relating motion of the cursor controller and the motion of the cursor on the screen. At one end of the scale, the controller must move the cursor control a greater distance for a unit of motion of the cursor on the screen than at the other end of the scale.

1. Place the cursor over the slide bar in the GAIN portion of the window
2. Press and hold Button A
3. While Button A is depressed slide the controller left or right.
4. When the desired setting is reached, release the trackball button.

Saving the Current Settings as the Default

1. Place the cursor in the box adjacent to the “Save as Default” message.
2. Click the A-button on the trackball. A check mark (✽) will appear in the box.
3. Place the cursor on the OK button and click the A-button on the trackball. This will close the window and save the current settings as the default.

Slider Tools

Slider tools are common in modern GUIs (e.g., Windows, X-windows), and most operate in a similar manner. This functionality shall be available in the EDA GUI. Slider tools are used to move the eye point so that information (or areas in a map display) currently outside the viewing area becomes visible. Typical vertical and horizontal slider tools are shown in Figure 3.3.1-10.

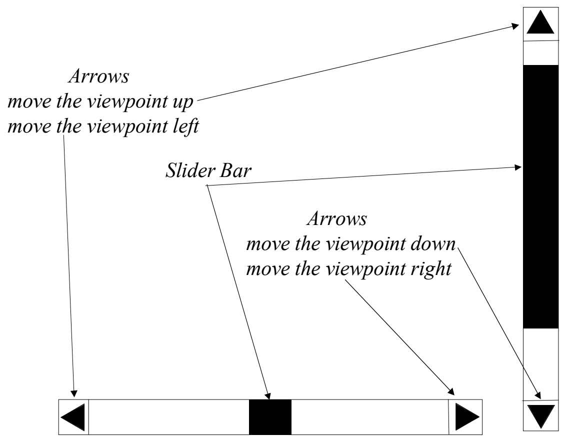

Figure 3.3.1-10. Examples of slider tools

General rules for implementing and using slider tools are:

- Vertical sliders shall always be located on the right edge of the window and vertical sliders shall always be located at the bottom of the window. (These positions were selected so that should a touch screen be added at some future time, the controller’s view of the display will not be blocked by their arm or hand. This assumes that the majority of the controllers will be right handed. It would be acceptable to provide an option allowing the vertical slider bar to be positioned on the left of the screen as a part of the system configuration menu. This would allow the system to better support left handed controllers. However, since we are not aware of any immediate plans to add a touch screen capability to DSR, this tool is not described here.)
- If all of the information available at that time is displayed in the window, the slider tool(s) shall not be displayed. If there is additional information in one direction (e.g., vertical) but not in the other, then only the relevant slider tool shall be displayed.
- The size of the slide bar will be related to the proportion of the data visible. If a small proportion of the data is visible in the window (e.g., there is a long list and only a few of the items can be displayed given the size of the window) then the slider bar will be small relative to the length of the control (as shown in the horizontal control in Figure 3.3.1-10). If the proportion of available data visible in the window is large, then the slider will be larger (as shown in the vertical control in Figure 3.3.1-10).
- To move the slider the controller places the cursor over the slider and presses and holds the A-button on the trackball.
    - When the cursor is on the slider in a vertical tool and the trackball’s A-button is pressed, upwards motion of the trackball (i.e., in the direction of the buttons) will move the slider upwards on the screen. Downwards motion of the trackball (i.e., away from the trackball buttons) will move the vertical slider downwards on the screen. Lateral motion of the

trackball when the cursor is in the vertical slider and the A-button on the trackball is depressed will have no effect.

- When the cursor is on the slider in a horizontal tool and the trackball's A-button is pressed, leftwards motion of the trackball will move the slider to the left on the screen. Rightwards motion of the trackball will move the slider towards the right side of the screen. Vertical motion of the trackball when the cursor is in the horizontal slider and the A-button on the trackball is depressed will have no effect.

Controlling Windows

There are a variety of windows and tools that can be selected for display by the controller. The controller shall have the ability to reposition and resize these windows, as well as having the capability to minimize the window or to close it completely. These windows are often accesses through the Tool Bar, the Map Option Fast Action Button Area, or by clicking on a specific aircraft. Figure 3.3.1-11 shows a generic window. The controller can minimize the window and, once a window has been minimized, restore it to its previous size. The controller can also maximize a window. These functions are described below.

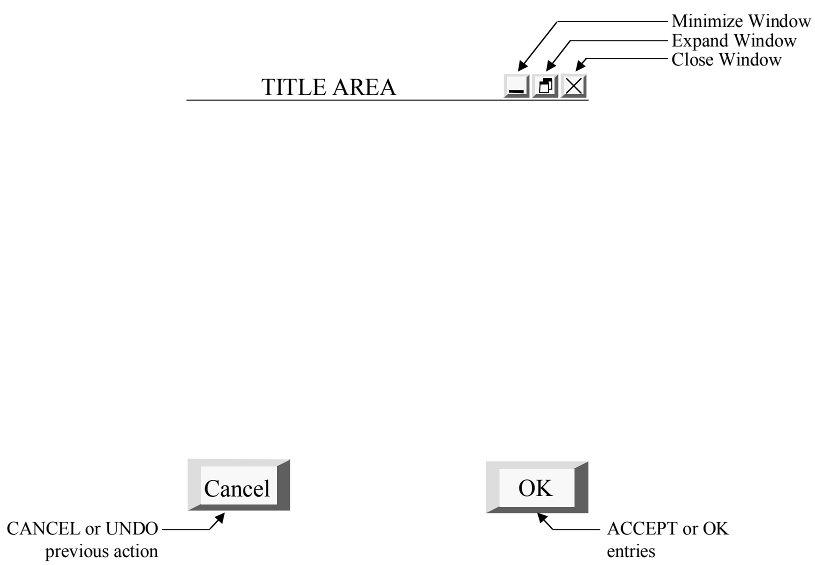

Figure 3.3.1-11. Generic Window showing typical controls

<u>Bring a Window Forward</u>

When all or part of a window is occluded by another window, the controller may bring it forward using one of two techniques.

Using the Window Buttons

1. Place the cursor over the button corresponding to the window along the bottom of the display. When the cursor is over a button that button shall be highlighted so that it is clear which button is selected.
2. Click the A-button on the trackball. When the trackball button is clicked, the window will be brought in front of the other windows that are open.

Hooking the Window

1. Place the cursor anywhere in the widow that is to be brought to the front. *(Note: This may require other windows be resized, moved, or minimized in order to make part of the window accessible.)*
2. Click the A-button on the trackball. The window will be moved in front of the other windows.

Minimizing a Window

1. Place the cursor over the "minimize" button. This button is located in the upper right hand portion of the window. When the cursor is over the button, the button will be highlighted.
2. Click the A-button on the trackball. The window will be removed from display area. The button representing the window at the bottom of the screen will change from the ON to the OFF position when the window is minimized.

Restoring (or Expanding) a Window

1. When a window has been opened but is currently minimized, the controller may restore the window to its previous location by placing the cursor over the button representing the window. (This button is along the bottom edge of the display.) When the cursor is over a button that button shall be highlighted so that it is clear which button is selected.
2. Click the A-button on the trackball. When the trackball button is clicked, the window will be restored on the display. If there is insufficient display area available then the open windows will be automatically re-scaled in vertical height so that all of the windows are displayed. (Re-scaling will likely result in the addition of vertical slider tools to the windows that did not have them previously.)

Repositioning a Window

1. Place the cursor in the window's TITLE AREA. When the cursor is in this area the TITLE AREA will be highlighted and the cursor will change to a double ended, vertical arrow (✿).
2. Press and hold the trackball's A-button.
3. Moving the trackball vertically will move the window vertically. As the window moves it will appear to in front of all other windows. Lateral motion of the trackball will have no effect on the position of the window.
4. When the window is in the desired location, release the A-button on the trackball.

Rescaling Windows

1. Place the cursor along the edge of the window to be rescaled. When the cursor is in a position to rescale a window vertically (i.e., on the upper or lower edge of the window) the cursor shall change from its normal shape to a double ended, vertical arrow (✿). When the cursor is in a position to rescale the window horizontally (i.e., on the left or right edge) the cursor shall change from its normal shape to a double ended, horizontal arrow (✿). Additionally, the title block of the window to be rescaled will highlight.
2. Press and hold the A-button on the trackball.
3. While the A-button is depressed, move the trackball vertically or horizontally to move the position of the edge of the window as desired.
4. When the edge is in the desired location, release the A-button on the trackball.

If a window cannot be rescaled then the cursor shall not change shape when it crosses the edge of that window.

Color Coding of Window Backgrounds

The colors of the backgrounds of the EDA windows shall be achromatic (i.e., gray). The background colors shall be selected so that there is adequate contrast between the background and the symbols and text displayed on the window.

In order to aid the controller in maintaining awareness of which windows contain information about Active Plans and which contain information about Provisional Plans, at least two background colors shall be used. One for the background in windows displaying information based on the Active Plan, and another for use in windows displaying information based on the Provisional Plan.

The same gray used in the Provisional Plan Window shall also be used in the Plan Acceptance and Provisional Conflict Windows. The background color of the Active Plan and Active Conflict Windows shall be the same, but a different color than that used for the windows containing provisional data.

The backgrounds of the Time Line Display and the Sequence List windows shall be color coded on a column-by-column basis. Columns containing information describing Active Plan information shall have the same background as the Active Plan Window. Columns containing data based on the Provisional Plan shall have the same background color as the Provisional Plan Window.

The available information is inadequate for determining whether the backgrounds of the Active Windows should be brighter or darker gray than Provisional Windows. In order to avoid delaying development of software, an arbitrary decision must be made. It is recommended that the initial EDA software provide the backgrounds brighter in the Provisional windows than in the Active Windows.

The use of background colors should be consistent in a Center. Consistent use will facilitate rapid understanding of the EDA display when one controller is being relieved by another, as well as by other controllers looking at the display.

Dwell

The EDA system shall provide additional information about a particular aircraft when the controller allows the cursor to dwell over the aircraft symbol or identifier for an extended period of time. The exact length of time for this feature to be activated is TBD.

When the cursor is placed over an aircraft symbol in map display, or over the aircraft identifier in any display, and the cursor remains stationary for the dwell duration, additional alphanumeric information automatically shall be displayed about that aircraft in the message window.

The alphanumeric information displayed shall be selected and organized in a "context sensitive" manner. For example, if the controller dwelled over an aircraft in a window addressing metering conformance, the information related to metering would take precedence in the list. If the dwell were in the Provisional Plan, information about that aircraft's provisional plan would take precedence. Additional work will be required to determine which information items should be displayed and the order in which they are displayed to best support the controller's intent for each window.

The controllers shall have the ability to set the dwell time to suite their individual preferences. This shall include the ability to turn the dwell function OFF. This setting shall be accessed through the System Configuration menu.

Buttons

Buttons used by the controller shall provide visual and auditory feedback. Auditory feedback shall consist of a short tone or click when the button changes state (i.e. when the controller clicks on the button.)

Visual feedback shall consist of the button changing from a raised appearance to a depressed appearance, or vice versa. Additional visual cueing to make the state of the button readily apparent to the controller is highly desired. Figure 3.3.1-12 shows typical buttons in the raised and depressed positions. The button is augmented by the inclusion of a circle on the button when it is depressed. This circle is not present when the button is in the raised position.

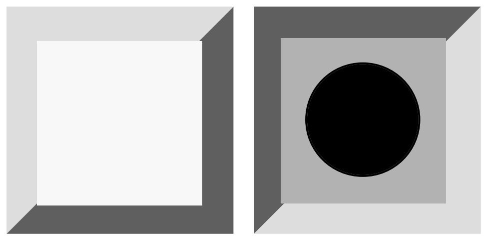

Figure 3.3.1-12. Buttons.

The button on the left shows the button before the controller has clicked on it. The button on the right shows the button after the controller has clicked on it. If this were a momentary button, it would not remain depressed, but would return to the raised state. If it is not a momentary button, then the button would remain in the depressed position until the controller clicks on the button to deselect that option.

<u>3.3.1.2.6</u> <u>Tool Bar Buttons</u>

This section lists the buttons that appear on the Tool Bar, and the options that are available on the pop up menu associated with each button.

System Setup Button

- Track ball setup menu
  - Left – Right handed
  - Acceleration
  - Gain
  - Double Click Speed
  - Save as default
- Metering List Window
- Dwell Time Setting
- CTAS/CAST menus
  - The menus available in CAST and CTAS that are used to control the display of menus shall be included here. It is expected that these menus will provide the controller the means to configure the display

Map Scale Button

- Scale 1
- Scale 2
- Scale 3
- Scale 4

- Scale 5
- Save as default

Conflict Probing Button

- Time probed (slider bar)
- Save as default

Conflict Resolution Setup Button

- Level of Automation
  - Automatic
  - Semi Automatic
  - Manual
  - Save as default
- Degrees of Freedom
  - Cruise speed
  - Descent speed
  - Lateral course deviation
  - Vertical deviation (altitude change)
  - Save as default

Metering Setup Button

- Level of Automation
  - Automatic
  - Semi Automatic
  - Manual
  - Save as default
- Degrees of Freedom
  - Cruise speed
  - Descent speed
  - Lateral course deviation
  - Vertical deviation (altitude change)
  - Save as default

Path Stretch Tool

- Type of stretch
  - S-turn
  - Deviate to left
  - Deviate to right
- Delay to be absorbed
  - MM:SS
- Time to be recovered (expedited)
  - MM:SS

Data Link

- Send Provisional Plan to Aircraft (provisional plan made active when the plan is entered into the aircraft's FMS
- Move a provisional plan sent from the aircraft (as part of trajectory negotiation) for example, to the provisional plan for controller evaluation and conflict probing, and metering assessment)

Share Provisional Plan

- Field to designate controller collaborating on solving the problem
    - Make provisional plan available to a specific controller

3.3.2 (Project-unique identifier of interface)

TBD

3.4 System Internal Interface Requirements

Figure 3.4-1[24] shows the relationships between the high-level EDA functions to satisfy the requirements of Section 3.2.

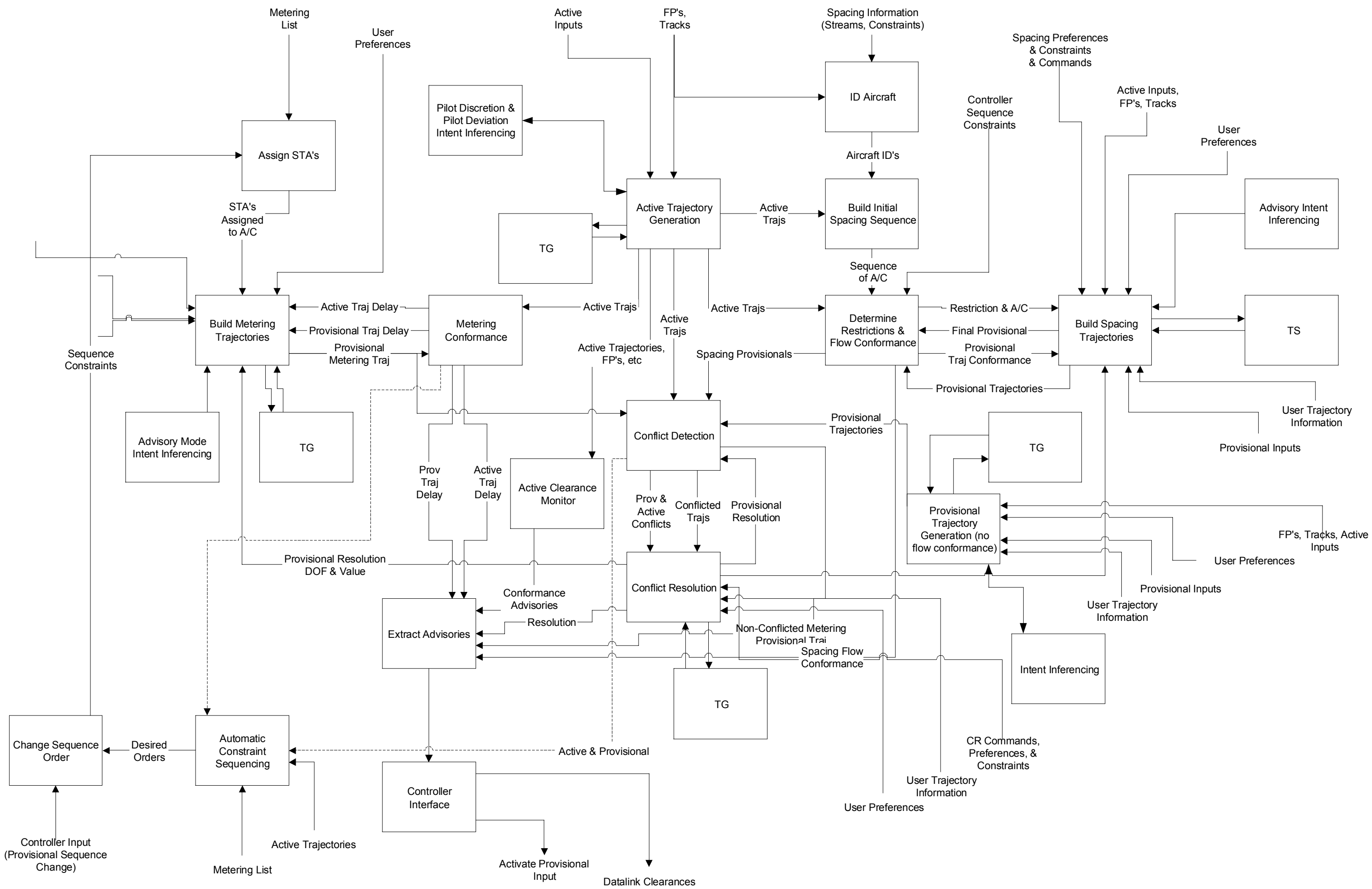

Figure 3.4-1: EDA Functional Flow Diagram

[24] The EDA Build 3 functional diagram assumes flow conformance advisories are added to the provisional plan trajectory and not to the active plan trajectory. This capability needs to be added in the future.

Figure 3.4-1 illustrates the relationships between the EDA functions by using arrows between the function boxes. On each line is the primary piece of information that causes the inter-relationship between the functions (e.g., the information one function must provide for the other). As the EDA design evolves and new functions and relationships are defined, more boxes and arrows will be added to diagram.

3.4.1 Use Cases

Execution of the EDA functions as shown in Figure 3.4-1 are illustrated by describing the various use cases for the system. A use case illustrates the order in which functions are executed based on system events. The use cases for EDA are broken up into three main categories: Track Update, Controller Input, and Metering Schedule Update. Each of these events causes EDA to update its predictions and advisories.

To simplify the explanation of each of these use cases, the following sub-cases are described:

- Track Update
    - Separation Assurance without Flow Conformance
    - Flow Conformance without Automatic Resolution
    - Flow Conformance with Separation Assurance
- Controller Input
    - Active Input
    - Provisional Input
- Metering Schedule Update

The sub-cases allow the illustration of the complete EDA functionality to be broken down into additive elements for easier understanding. Future use cases for TBD functionality (e.g., user trajectory negotiation) will be added to this list as developed.

3.4.1.1 Track Update

When a track update is received by EDA from the Host Computer, all trajectory prediction and EDA functionality (e.g., separation assurance, flow conformance, etc.) are updated. This is the "basic cycle" of EDA, and will be described in three sub-cases:

- Separation Assurance (No Flow Conformance)
- Flow Conformance (Conflict Detection Only)
- Flow Conformance with Separation Assurance (Conflict Detection and Resolution)

3.4.1.1.1 Separation Assurance (No Flow Conformance)

The first use case illustrates the sequential flow of the EDA system functions for separation assurance for aircraft without flow conformance constraints (see Figure 3.4.1-1).

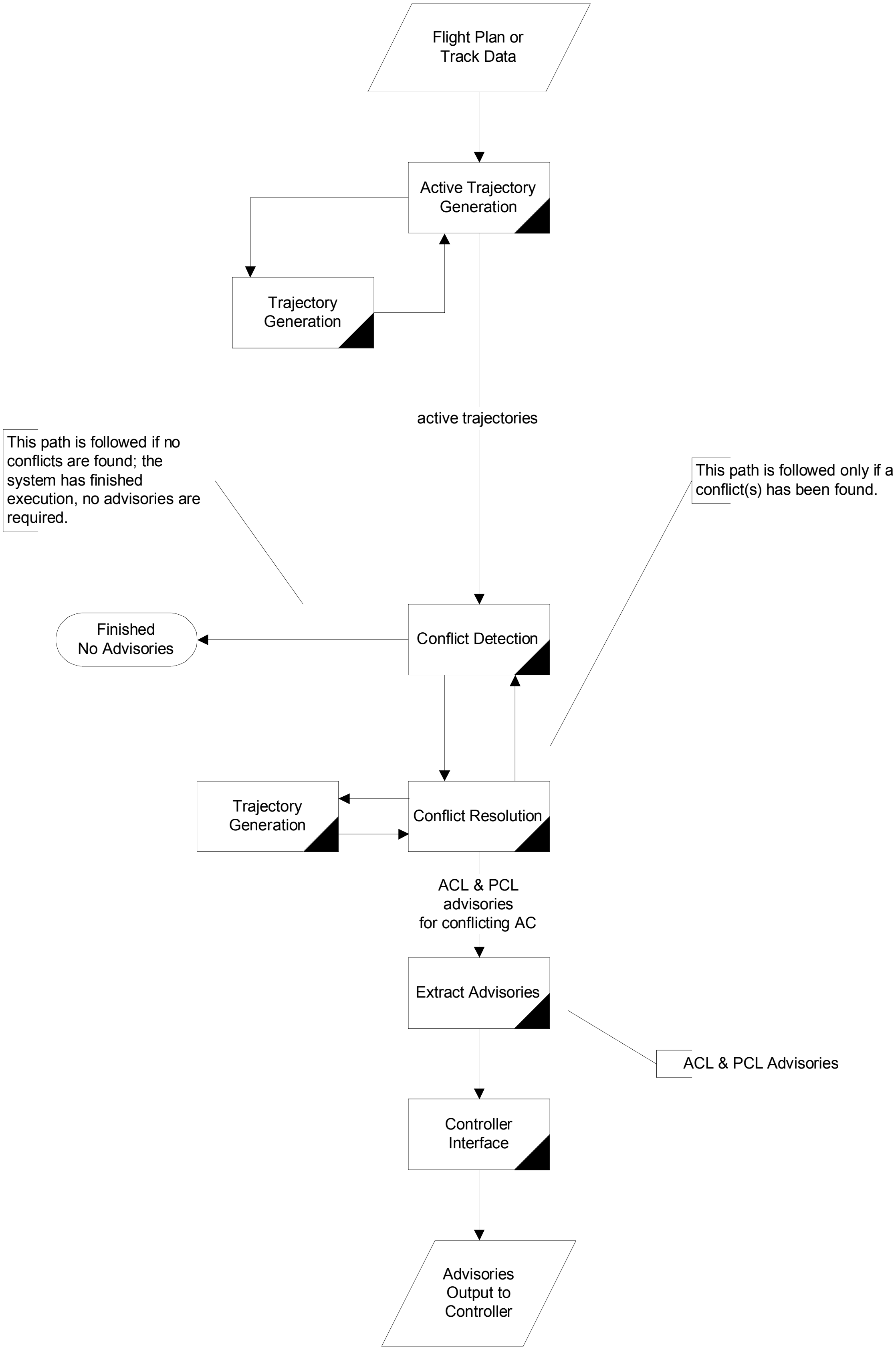

Figure 3.4.1-1. Sequential flow of EDA functionality for separation assurance (no flow conformance)

As shown in Figure 3.4.1-1, the EDA system is invoked by reception of new track data from the Host Computer. This event results in the need to update both the active and provisional plan trajectories. This is the first action performed in Figure 3.4.1-1 and is executed by *Active Trajectory Generation* and *Provisional Trajectory Generation*. *Active Trajectory Generation* uses the new track, flight plan, and any active inputs to generate lateral and vertical path constraints, which are passed to *Trajectory Generation. Trajectory Generation* returns a linearly interpolatable trajectory back to *Active Trajectory Generation*. Similarly, *Provisional Trajectory Generation* uses the new track, flight plan, and any active and provisional inputs to generate lateral and vertical path constraints, which are passed to *Trajectory Generation,* and receives back a linearly interpolatable trajectory. Next, all active and provisional plan trajectories received by *Conflict Detection* are probed for conflicts with all other active and provisional trajectories in the system. If no conflicts are found, the system is finished performing all necessary tasks required for separation assurance; no advisories are sent to the controller.

If at least one conflict has been detected, the active conflict list and provisional conflict list are passed to *Conflict Resolution*. *Conflict Resolution* cycles through all resolvable conflicts (as described in section 3.2.4.2.3) and determines solutions for each conflict in the Resolution Conflict List (RCL). As described earlier, *Conflict Resolution* may determine that no resolution maneuver is possible and at other times may create new resolution maneuvers by passing DOF values to *Trajectory Generation*, which returns linearly interpolatable trajectories back to *Conflict Resolution*. *Conflict Resolution* passes these resolution trajectories to *Conflict Detection* where they are probed for conflicts. The conflict status for these trajectories (i.e., whether they were conflict free or not) is passed back to *Conflict Resolution*. *Conflict Resolution* determines if it has finished searching for resolution maneuvers (because either all conflicts have been resolved or all DOFs maxed out). If the search is not finished the *Conflict Resolution/Trajectory Generation/Conflict Detection* cycle is repeated. If the search is complete, *Extract Advisories* is executed. This function obtains all ACL/PCL conflict advisories and their corresponding maneuver advisories. This information is passed on to the *Controller Interface* where the data is prepared and formatted for display to the controller.

3.4.1.1.2 Flow Conformance (Conflict Detection Only)

Figure 3.4.1-2 illustrates the sequential flow of the EDA system functions for flow conformance without automatic conflict resolution (i.e., conflict detection only). The system is invoked by the reception of new track data from the Host.

The first actions performed under this use case are for *Active Trajectory Generation* and *Provisional Trajectory Generation* to use the track/flight plan data to build active and provisional plan trajectories with *Trajectory Generation* (as in the previous use case). The provisional plan trajectories generated in *Provisional Trajectory Generation* are for non-flow constrained aircraft only (flow conformance aircraft are covered next). As in the previous use case, the active and provisional plan trajectories are sent to *Conflict Detection* for probing (probing does not occur until provisional plan trajectories for flow constrained aircraft are created, as described next). The active plan trajectories from *Active Trajectory Generation* are also passed to *Metering Conformance*. *Metering Conformance* determines whether or not each active trajectory is conformant with its metering constraint (e.g., a metered aircraft's active plan trajectory has no remaining delay to absorb to meet its STA). Active trajectory flow conformance information (e.g., delay) is passed from *Metering Conformance* to *Extract Advisories* as shown in Figure 3.4.1-2. All active trajectories that are not flow conformant are then passed on to *Build Metering Trajectories*. For each aircraft, *Build Metering Trajectories* determines allowable flow conformant degree of freedom values and adds these flow conformance trajectory modifications to existing track, flight plan, active input and provisional input data to generate new lateral and vertical constraints for a flow conformant provisional plan trajectory. *Build Metering Trajectories* passes these values on to *Trajectory Generation*, which returns a linearly interpolatable trajectory. This trajectory is passed on to *Metering Conformance*, which determines if the metering constraints are now met, and then passes any remaining delay on to *Build Metering Trajectories*. If the solution is not flow conformant the process is repeated

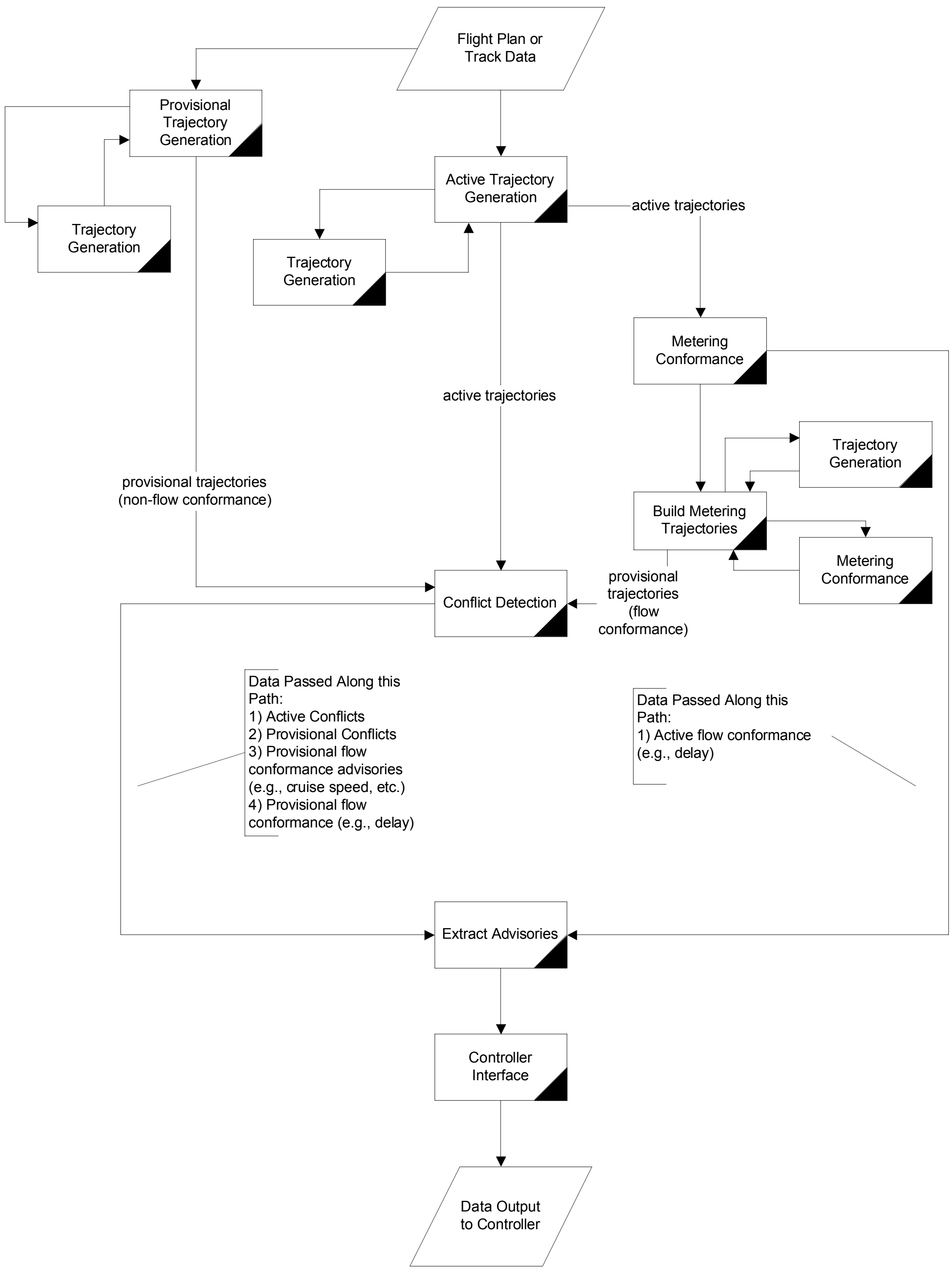

Figure 3.4.1-2. Sequential flow of EDA functionality for flow conformance without automatic conflict resolution

again until a flow conformant solution is obtained or *Build Metering Trajectories* determines that a solution cannot be found (e.g., due to controller imposed constraints in flow conformance DOFs). Once *Build Metering Trajectories* has finished, all provisional plan trajectories for the flow-constrained aircraft are passed to *Conflict Detection.*

When *Conflict Detection* receives all active and provisional plan trajectories, they are probed for conflicts. All active and provisional conflict information is then sent to *Extract Advisories*, which in turn passes this information along to the *Controller Interface* for display. Along the same path between *Conflict Detection* and *Extract Advisories*, provisional flow conformance information (e.g., delays for metered aircraft with provisional plan flow conformance trajectories) and flow conformance advisory information (e.g., cruise speed, etc.) is passed on to *Extract Advisories* (recall that active flow conformance advisory information was sent directly from *Metering Conformance*).

3.4.1.1.3 Flow Conformance With Separation Assurance (Conflict Detection and Resolution)

Figure 3.4.1-3 illustrates the sequential flow of the EDA system functions for flow conformance with separation assurance. The system is invoked by the reception of new track data from the Host as described in Section 3.4.1.1.1.

This use case begins with the exact same processing as described in the previous use case (see Section 3.4.1.1.2). After all of the active and provisional (flow conformance and non-flow conformance) plan trajectories are received and probed by *Conflict Detection*, the ACL and PCL are sent to *Conflict Resolution*. All provisional plan trajectories that are conflict free or for which resolution advisory generation is not to be performed (see Section 3.2.4.2.3) are passed directly to *Extract Advisories* as shown in Figure 3.4.1-3. The information passed along this path consists of 1) provisional flow conformance (e.g., delay) for all conflict free aircraft and 2) provisional flow conformance advisories (e.g., cruise speed) for all conflict free aircraft. Conflict free aircraft are defined as aircraft that are not in the ACL or PCL.

All ACL and PCL trajectories are passed from *Conflict Detection* to *Conflict Resolution*. For all aircraft without flow conformance constraints or for aircraft where flow conformance advisory generation is over-ridden by conflict resolution advisory generation (see Section 3.2.4.2.3), *Conflict Resolution* determines the resolution DOFs and their respective values and iterates with *Trajectory Generation* and *Conflict Detection* to resolve the conflict (see the first use case, Section 3.4.1.1.1, for description of resolution for aircraft without flow conformance).

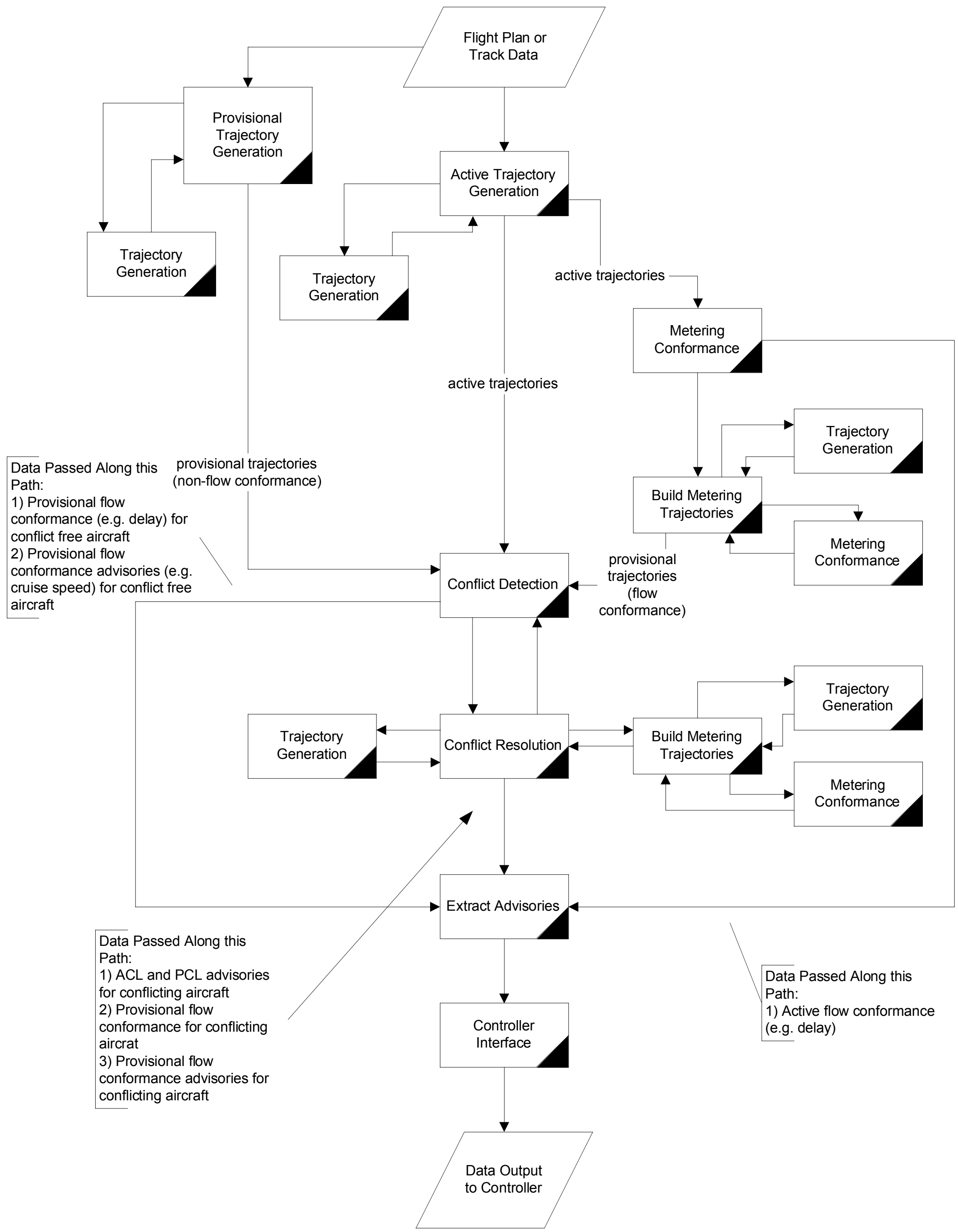

Figure 3.4.1-3. Sequential flow of EDA functionality for flow with separation assurance

For aircraft with flow conformance constraints, *Conflict Resolution* determines the DOFs to be used for conflict resolution and flow conformance and calculates the DOF values for the conflict resolution DOFs. This information is passed on to *Build Metering Trajectories*, which selects the value for the flow conformance DOF(s). All DOF values for both resolution and flow conformance and track, flight plan, active input and provisional input data are used to generate lateral and vertical constraints for the aircraft. This data is passed on to *Trajectory Generation*, which builds a linearly interpolatable trajectory and returns it to *Build Metering Trajectories*. *Build Metering Trajectories* passes this trajectory to *Metering Conformance*, which determines if the trajectory is flow conformant. If the trajectory is not flow conformant *Build Metering Trajectories* determines a new flow conformance DOF value and the process is repeated until a flow conformant trajectory is found or the flow conformance DOF maxes out[25]. If a flow conformant trajectory is found, *Build Metering Trajectories* returns this trajectory to *Conflict Resolution*. *Conflict Resolution* passes this trajectory to *Conflict Detection* where it is probed for conflicts. If the trajectory is not conflict free, *Conflict Resolution* determines new resolution DOFs and/or DOF values and/or new flow conformance DOFs (see Section 3.2.4.2.3). Conflict Resolution finishes once all conflicts have been solved or all DOF possibilities exhausted.

Once *Conflict Resolution* has completed all required actions, the following information is sent from *Conflict Resolution* to *Extract Advisories*: 1) ACL and PCL advisories for all conflicting aircraft, 2) Provisional flow conformance for all conflicting aircraft (e.g., delay), and 3) Provisional flow conformance advisories for all conflicting aircraft (e.g., cruise speed).

Extract Advisories passes all required information on to the *Controller Interface*, which prepares and formats the data for display to the controller.

3.4.1.2 Controller Input

When a controller input, either active or provisional, is received by EDA in between track updates, EDA must immediately calculate new trajectory predictions and advisories based on the input without waiting for a new track update.

3.4.1.2.1 Active Controller Input

Figure 3.4.1-4 illustrates the sequential flow of the EDA system functions when an active input (see Section 3.2.1.1) is entered by the controller.

The first action performed by the system when the controller enters an active input is the building of a new active plan trajectory for the impacted aircraft by *Active Trajectory Generation*. If the aircraft also has provisional inputs and no metering constraint, then *Provisional Trajectory Generation* builds a new provisional plan trajectory. If the aircraft has a metering constraint, then the active plan trajectory is sent to *Metering Conformance* to see if *Build Metering Trajectories* needs to develop a new provisional plan flow conformance trajectory. Once a new active plan and provisional plan (if provisional inputs or metering constraint) trajectory is built, all actions performed by the system are the same as for those described for Figure 3.4.1-3 in Section 3.4.1.1.3; the only difference being that the process here is performed for only one aircraft.

[25] If the flow conformance DOF maxes out, *Build Metering Trajectories* returns to *Conflict Resolution* which restarts the *Build Metering Trajectories/Trajectory Generation/Metering Conformance* iteration again with new resolution DOFs and/or DOF values (see section 3.2.4.2.2 for further details).

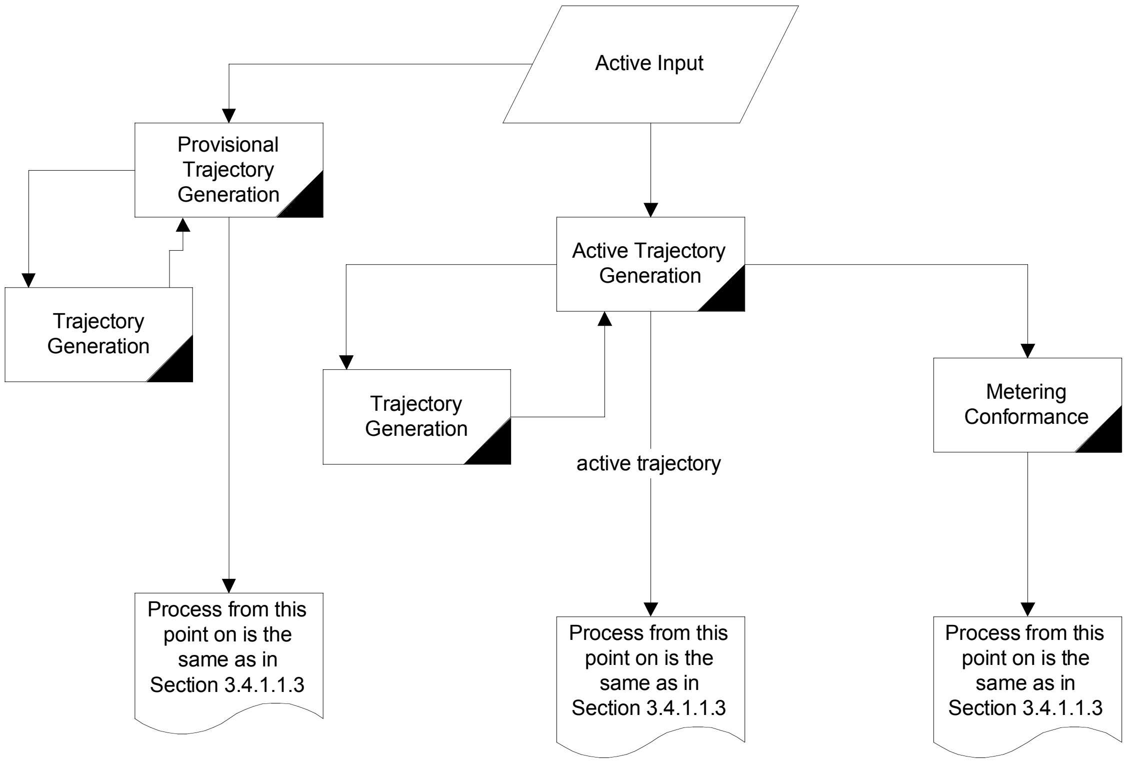

Figure 3.4.1-4. Sequential flow of EDA functionality for active controller input

3.4.1.2.2 Provisional Controller Input

Figure 3.4.1-5 and 3.4.1-6 illustrate the sequential flow of the EDA system functions when a provisional input (see Section 3.2.1.2) is entered by the controller. There are two sub-cases for provisional plan inputs:

1. Provisional constraints placed on aircraft with/without flow conformance constraints or a Flow Conformance (advisory generation or DOF selection) mode change to an aircraft with flow conformance constraints.

2. A Conflict Resolution (advisory generation or DOF selection) mode change to an aircraft.

Figure 3.4.1-5 illustrates the sequential flow of the EDA system functions for a non-resolution mode change provisional input for an aircraft with/without flow conformance constraints.

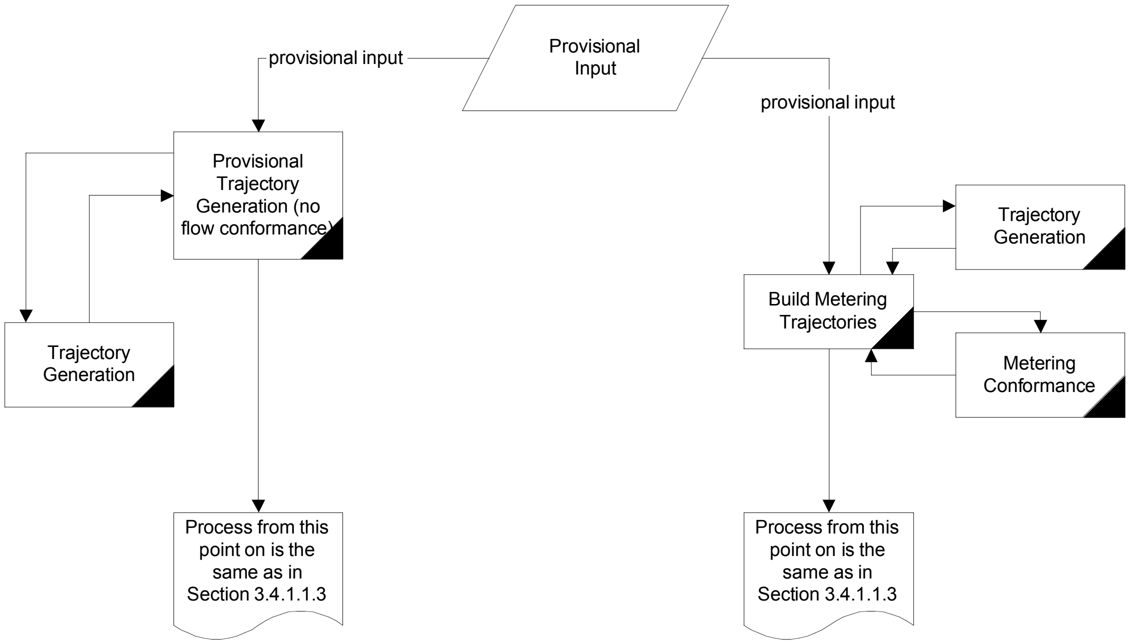

Figure 3.4.1-5. Sequential flow of EDA functionality for non-resolution mode provisional input

If the provisional input is for a non-flow constrained aircraft, the aircraft's provisional plan trajectory is updated by *Provisional Trajectory Generation* and sent to *Conflict Detection* for probing. The rest of this use case follows the use case description in Section 3.4.1.1.3; the only difference being that the process here is performed for only one aircraft.

If the provisional input is for an aircraft with a flow conformance constraint, *Build Metering Trajectories* builds the new flow conformance provisional plan trajectory, iterating with *Metering Conformance* and *Trajectory Generation* as necessary. The rest of this use case follows the use case description in Section 3.4.1.1.3; the only difference being that the process here is performed for only one aircraft.

Figure 3.4.1-6 illustrates the sequential flow of the EDA system functions for a resolution mode change provisional input for an aircraft. Execution for this event requires that PCL information prior to the original operation of *Conflict Resolution* is stored in memory. This PCL information represents the original provisional information for a track update, flight update, or controller input (active or provisional) prior to execution of *Conflict Resolution* during the last track update. This information needs to be stored so that if a resolution mode is changed by the controller, the resolution algorithm begins its search for a solution using this initial data.

If the algorithm has the original (pre-resolution) PCL and the updated resolution mode for the aircraft, iteration to resolve the conflict can begin. If the aircraft has a flow conformance constraint, the iteration between *Conflict Resolution* and *Build Metering Trajectories* is performed. If no flow conformance constraint exists, then iteration occurs between *Conflict Resolution* and *Trajectory Generation*. The rest of this use case follows the use case description in Section 3.4.1.1.3; the only difference being that the process here is performed for only one aircraft.

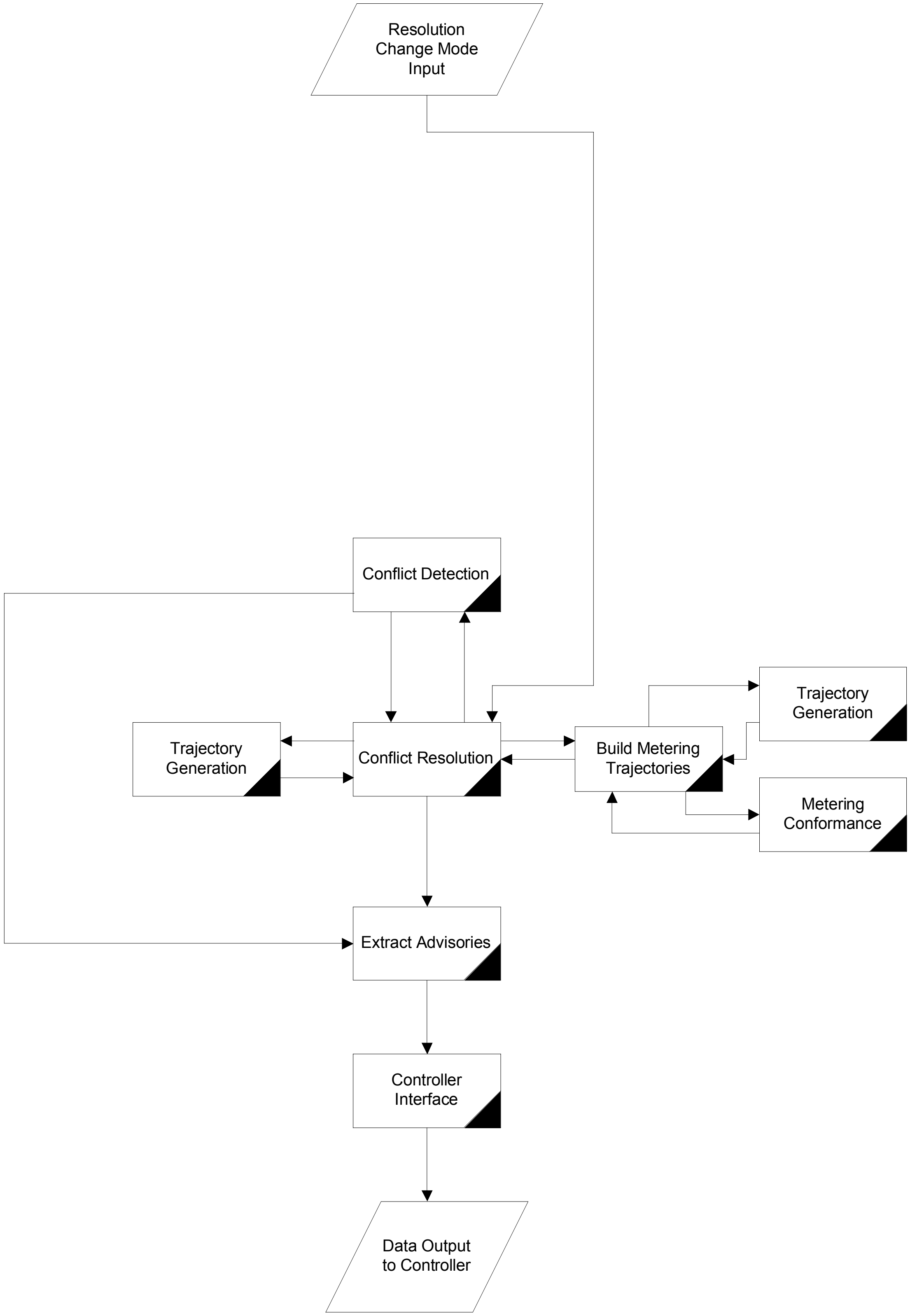

Figure 3.4.1-6. Sequential flow of EDA functionality for resolution mode change

3.4.1.3 Metering Schedule Update

When a new list of STAs is received by EDA from TMA, EDA must immediately update the metering conformance and metering advisories for aircraft whose STAs have changed, without waiting until the next track/flight plan update.

Figure 3.4.1-7 illustrates the sequential flow of the EDA system functions when a scheduling update occurs. The first action is reception of the new metering restrictions, which are passed from the TMA to *Assign STAs*. *Assign STAs* assigns the scheduled time of arrival for each aircraft and passes this information on to *Build Metering Trajectories*. *Build Metering Trajectories* creates flow conformant trajectories for each via the *Build Metering Trajectories/Trajectory Generation/Metering Conformance* iteration process discussed previously. Once flow conformant trajectories are built, they are passed to *Conflict Detection* where they are probed for conflicts. The rest of this use case follows the same process as in Section 3.4.1.2.2 for provisional input changes to the provisional plan flow conformance trajectory.

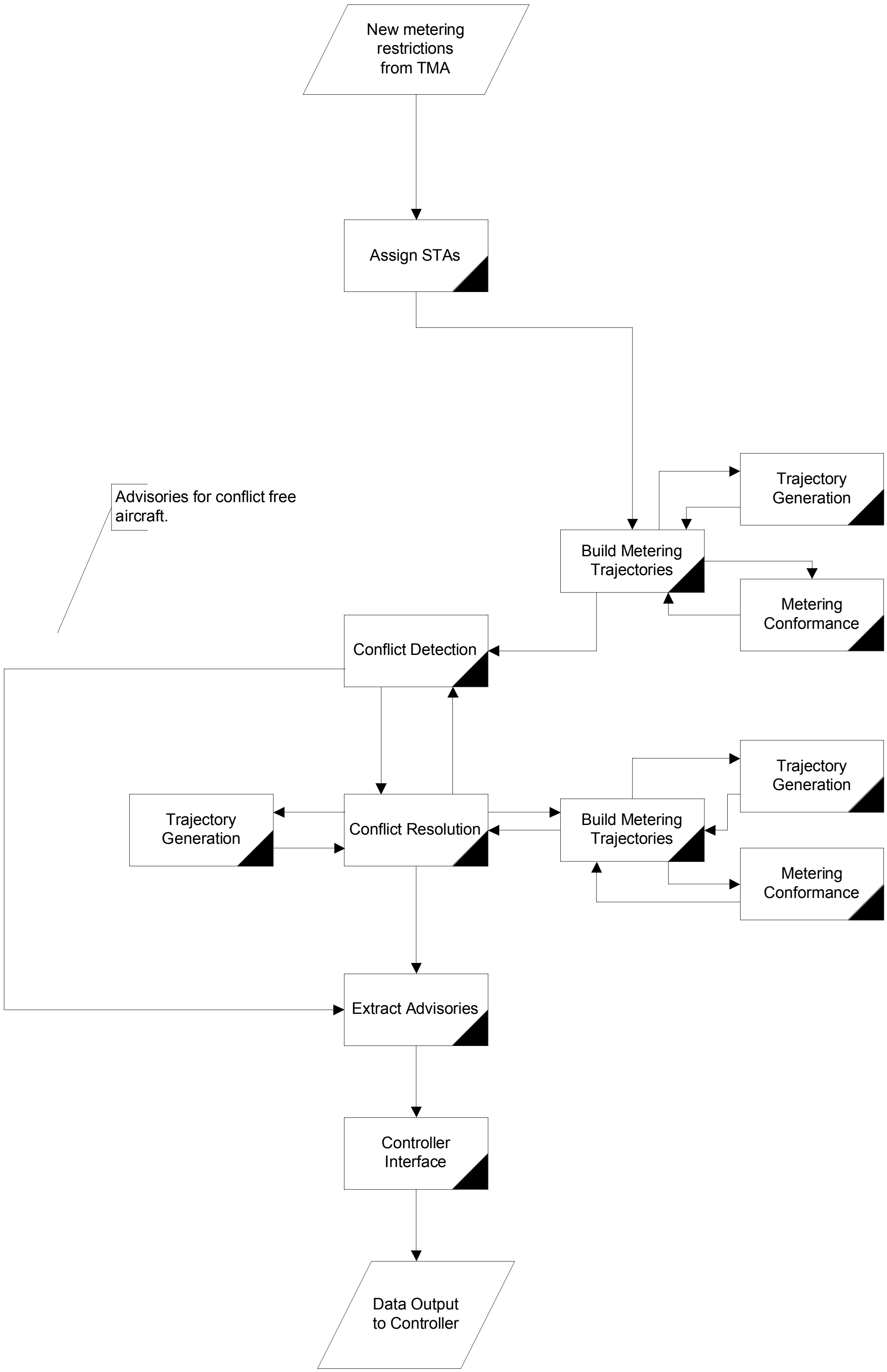

Figure 3.4.1-7. Sequential flow of EDA functionality for a scheduling update

3.5 System Internal Data Requirements

EDA does not require any specific internal data requirements. All decisions regarding internal data shall be regulated by the software design.

3.6 Adaptation Requirements

There are no additional adaptation requirements identified for EDA beyond those that already exist for CTAS adaptation required for integration with the Host Computer.

3.7 Safety Requirements

There are no additional safety requirements for EDA beyond those currently imposed on CTAS.

3.8 Security and Privacy Protection Requirements

TBD

3.9 System Environment Requirements

The EDA system shall be implemented within the CTAS baseline. All coding and system environment standards specified for the CTAS baseline (e.g., hardware, operating system, languages) as described in the CTAS Coding Standards [5, 6, 7] apply to EDA.

The interface for EDA shall support both workstation and DSR platforms.

3.10 Computer Resource Requirements

3.10.1 Computer Hardware Requirements

EDA shall follow CTAS hardware guidelines implicit in development within the CTAS baseline. Interface hardware shall include both Sun workstation and DSR platforms.

3.10.2 Computer Hardware Resource Utilization Requirements

TBD.

Note: Hardware must support the additional computational loads imposed by EDA due to CD&R for both active and provisional plan trajectories.

3.10.3 Computer Software Requirements

EDA shall follow the CTAS coding standards specified in reference 5.

3.10.4 Computer Communications Requirements

No additional requirements are expected for EDA beyond those already required for CTAS. Additional requirements may be added in the future in order to support datalink.

3.11 System Quality Factors

TBD.

3.12 Design and Construction Constraints

EDA must be developed within the CTAS baseline. All CTAS coding standards [5, 6, 7] apply.

3.13 Personnel-Related Requirements

TBD.

3.14 Training-Related Requirements

TBD.

3.15 Logistics-Related Requirements

TBD.

3.16 Other Requirements

None.

3.17 Packaging Requirements

TBD.

3.18 Precedence and Criticality Requirements

All requirements given in this document have equal weight.

4.0 Qualification Provisions

TBD.

5.0 Requirements Traceability

This section provides the requirements derived from the primary and secondary source documents and their traceability to these documents. The section is broken into sub clauses based on EDA defined functionality.

5.1.1 Flow Rate Conformance

5.1.1.1 Metering

Number	Requirement Statement	Verbatim Statement	Source Document	Section
MT-1	EDA shall assist controllers in the metering of traffic	▪ to assist controllers to enable user-preferred metering ▪ the flow-rate conformance capabilities (for arrival metering or en route spacing) allow the controller to plan and implement fuel-efficient clearances for conformance. ▪ Trajectory-oriented solutions are enabled by providing controllers with active flow-rate-conformance advisories (integrated with CD&R capabilities) and accurate 4D-trajectory predictions.	Milestone 5.10 Milestone 5.10 Milestone 5.10	Sec 1.1 Sec 3.1.1 Sec 4.0
MT-2	EDA shall incorporate user preferences into metering	▪ to assist controllers to enable user-preferred metering	Milestone 5.10	Sec 1.1
MT-3	EDA shall support the controller in planning and implementing fuel-efficient clearances for conformance to metering constraints	▪ the flow-rate conformance capabilities (for arrival metering or en route spacing) allow the controller to plan and implement fuel-efficient clearances for conformance. ▪ EDA provides fuel-efficient advisories for flow-rate conformance and integrates those advisories with conflict detection and resolution (CD&R) capabilities. ▪ DA also generates clearance advisories based on fuel-efficient Descent Profiles.	Milestone 5.10 Milestone 5.10 CSC DA FD 5/98	Sec 3.1.1 Sec 1.1 Sec 3.8.2

MT-4	EDA will provide active flow-rate conformance advisories for metering	▪ Trajectory-oriented solutions are enabled by providing controllers with active flow-rate-conformance advisories (integrated with CD&R capabilities) and accurate 4D-trajectory predictions. ▪ These functions generate the EDA advisories for flow-rate conformance. ▪ Build 3 will include flow-conformance advisories, integrated CD/R with resolution advisories for metered and non-metered flights, automation for inter-sector coordination, fast controller inputs and provisional planning, and some limited integration of experimental communication, navigation, surveillance (CNS) capabilities	Milestone 5.10 Milestone 5.10 TO45 SOW	Sec 4.0 Sec 4.2 Sec I
MT-5	EDA metering clearances shall be integrated with CD&R (separation assurance)	▪ Trajectory-oriented solutions are enabled by providing controllers with active flow-rate-conformance advisories (integrated with CD&R capabilities) and accurate 4D-trajectory predictions.	Milestone 5.10	Sec 4.0
MT-6	EDA shall assist the controller with the planning of delay maneuvers for metering	▪ ATC automation tools assist the controller with the planning of delay maneuvers	Milestone 5.10	Sec 2.1
MT-7	EDA shall assist the controller in selecting the most efficient delay absorption techniques	▪ This automation would enable controllers to select more efficient delay absorption techniques (e.g., speed reduction) and begin delay actions earlier with smaller deviations.	Milestone 5.10	Sec 2.1
MT-8	EDA shall provide "active" meet-time advisories for fuel-efficient conformance to metering constraints	• "Active" meet-time advisories for fuel-efficient conformance to flow-rate constraints (i.e., arrival metering or spacing) ▪ Trajectory-oriented solutions are enabled by providing controllers with active flow-rate-conformance advisories (integrated with CD&R capabilities) and accurate 4D-trajectory predictions. ▪ The primary benefit of DA is automated generation of descent advisories that meet	Milestone 5.10 Milestone 5.10 CSC DA FD 5/98	Sec 3.0 Sec 4.0 Sec 3.8

		STAs.		
MT-9	EDA shall detect flow-rate conformance problems up to 20 minutes in the future (1-2 sectors)	• EDA will accurately detect separation and flow-rate conformance problems up to 20 minutes into the future (generally across 1-2 sectors).	RTO34B	Sec 2
MT-10	EDA shall integrate metering conformance advisories with conflict detection and resolution	▪ EDA provides fuel-efficient advisories for flow-rate conformance and integrates those advisories with conflict detection and resolution (CD&R) capabilities. ▪ integrates those advisories with conflict detection and resolution (CD&R) capabilities ▪ it is necessary to integrate DST capabilities for flow-rate conformance and conflict detection and resolution (CD&R) ▪ Integration of flow-rate-conformance advisories with CD&R to reduce controller workload in the planning, monitoring, and conformance of flow-rate restrictions and separation assurance. ▪ The development of DST capabilities for "strategic" flow-rate conformance, and their integration with CD&R capabilities, will minimize ATC interruptions. ▪ Trajectory-oriented solutions are enabled by providing controllers with active flow-rate-conformance advisories (integrated with CD&R capabilities) and accurate 4D-trajectory predictions. ▪ The piece de resistance of EDA is the integration of CD&R and flow-rate conformance capabilities. ▪ the EDA technology concept emphasizes two key aspects: a flexible suite of advisory capabilities; and integration of CD&R and flow-rate conformance advisories. ▪ Build 3 will include flow-conformance advisories, integrated CD/R with resolution advisories for metered and non-metered flights,	Milestone 5.10 Milestone 5.10 Milestone 5.10 Milestone 5.10 Milestone 5.10 Milestone 5.10 Milestone 5.10 Milestone 5.10 TO45 SOW	Sec 1.1 Sec 1.1 Sec 2.0 Sec 3.0 Sec 3.1.3 Sec 4.0 Sec 4.2 Sec 4.2 Sec I

		automation for inter-sector coordination, fast controller inputs and provisional planning, and some limited integration of experimental communication, navigation, surveillance (CNS) capabilities		
MT-11	EDA shall provide planning, monitoring, and conformance tracking of metering constraints	▪ integrates those advisories with conflict detection and resolution (CD&R) capabilities ▪ it is necessary to integrate DST capabilities for flow-rate conformance and conflict detection and resolution (CD&R) ▪ Integration of flow-rate-conformance advisories with CD&R to reduce controller workload in the planning, monitoring, and conformance of flow-rate restrictions and separation assurance. ▪ The development of DST capabilities for "strategic" flow-rate conformance, and their integration with CD&R capabilities, will minimize ATC interruptions. ▪ Trajectory-oriented solutions are enabled by providing controllers with active flow-rate-conformance advisories (integrated with CD&R capabilities) and accurate 4D-trajectory predictions. ▪ The piece de resistance of EDA is the integration of CD&R and flow-rate conformance capabilities.	Milestone 5.10 Milestone 5.10 Milestone 5.10 Milestone 5.10 Milestone 5.10 Milestone 5.10	Sec 1.1 Sec 2.0 Sec 3.0 Sec 3.1.3 Sec 4.0 Sec 4.2
MT-12	EDA shall provide "strategically-accurate" flow rate conformance advisories: advising a plan that is nominally in conformance rather than dividing up the responsibility over space and time	▪ The development of DST capabilities for "strategic" flow-rate conformance, and their integration with CD&R capabilities, will minimize ATC interruptions. ▪ Trajectory-oriented solutions are enabled by providing controllers with active flow-rate-conformance advisories (integrated with CD&R capabilities) and accurate 4D-trajectory predictions.	Milestone 5.10 Milestone 5.10	Sec 3.1.3 Sec 4.0
MT-13	EDA shall allow the controller to manually	▪ the controller may have selected an automatic	Milestone 5.10	Sec 4.1

	adjust automatic resolution advisories	cruise/descent-speed advisory for metering, but wishes to manually adjust the descent speed (e.g., trial plan) for conflict resolution. ▪ Controller choice (analogous to the "Trial Planning") ▪ with EDA, the controller may leverage the manual planning capability to "trial plan" a flow-rate conformance solution.	Milestone 5.10 Milestone 5.10	Table 2 Sec 4.2
MT-14	EDA shall support the meeting of scheduled times of arrival at the metering fix	▪ Speed profile advisories may be generated in three modes: Cruise-only; Descent-only; and Cruise-Plus-Descent. ▪ In Cruise-only, EDA iterates within the aircraft's cruise-speed envelope to determine a new cruise speed to meet the time at a meter fix. ▪ In Descent-only, EDA iterates within the descent-speed envelope to determine a descent-speed profile (Mach/KIAS) to meet the time. ▪ In Cruise-Plus-Descent, EDA iterates on both descent and cruise-speed profiles.	Milestone 5.10 Milestone 5.10 Milestone 5.10 Milestone 5.10	Sec 4.2 Sec 4.2 Sec 4.2 Sec 4.2
MT-15	EDS advisories shall meet scheduled times of arrival within approximately plus/minus 10 seconds	▪ the AERA 2 requirement for time of arrival for metering was plus/minus one minute whereas EDA was approximately 10 seconds.	RTO34B	Sec 5.5
MT-16	EDA shall maximize the use of speed envelopes for maintaining scheduled times of arrival	▪ EDA utilizes the same approach as used by flight management system (FMS) algorithms. One feature of FMS is to maximizes the use of the speed envelope for maintaining required times of arrivals.	RTO34B	Sec 5.5
MT-17	Metering conformance detection and resolution shall be fully configurable by controllers so that preferences can be set and saved.	▪ Conflict detection/resolution capabilities and the associated interfaces should be fully configurable by the controller so that preferences can be set and saved. Some examples of preferences that controllers requested: • Detection time horizon for conflicts should be adjustable in the range of 5-20 min • Detection time horizon for flow-rate	RTO34B	Sec 8.2

		conformance problems should be adjustable in the range of 5-20 min • Resolution time horizon for conflicts should be adjustable in the range of 5-20 min • Resolution time horizon for flow-rate conformance problems should be adjustable in the range of 5-20 min • Separation minima that will signal an alert should be adjustable in the range of 5-15 nm		
MT-18	Metering preferences shall include time horizon for conformance problem detection (5-20 min) and resolution (5-20 min)	▪ Conflict detection/resolution capabilities and the associated interfaces should be fully configurable by the controller so that preferences can be set and saved. Some examples of preferences that controllers requested: • Detection time horizon for conflicts should be adjustable in the range of 5-20 min • Detection time horizon for flow-rate conformance problems should be adjustable in the range of 5-20 min • Resolution time horizon for conflicts should be adjustable in the range of 5-20 min • Resolution time horizon for flow-rate conformance problems should be adjustable in the range of 5-20 min • Separation minima that will signal an alert should be adjustable in the range of 5-15 nm	RTO34B	Sec 8.2
MT-19	Advisories are determined by iterating on degrees of freedom (DOF) to meet metering constraints	• Advisories are determined by iterating on “degrees-of-freedom” (DOFs) and attempt to meet traffic management constraints such as TMA-generated meter-fix STAs.	CSC DA FD 5/98	Sec 3
MT-20	Advisories are compliant with crossing restrictions and similar to those generated for advanced onboard Flight Management Systems (FMS)	• Advisories are compliant with MF Crossing Restrictions and similar to those generated from advanced onboard Flight Management Systems (FMS).	CSC DA FD 5/98 CSC DA FD 5/98	Sec 3 Sec 3.8.1

		• DA advisories are compliant with MF Crossing Restrictions,		
MT-21	EDA flow conformance functionality shall be configurable by controllers	• Controllers can tailor the operational characteristics of DA.	CSC DA FD 5/98	Sec 3.8.1
MT-22	EDA shall maximize FMS utilization	• [EDA functions:] efficient descent planning, clearance advisory and monitoring - compatible with airborne FMS-LNAV/VNAV (maximizes FMS utilization)	Steve email 1/14/98	
MT-23	EDA shall allow the controller to swap the sequence of two aircraft in the metering list or enter up to 5 aircraft in a preferred sequence for TMA	• The sector controller can reorder the meter list sequence with either the manual swap (XB) message or the resequence meter list (XC) message. XB simply swaps two aircraft whereas XC allows the controller to enter up to 5 aircraft in his/her preferred sequence	Shawn England email 9/29/00	
MT-24	EDA shall generate automatic sequence constraints for TMA	• We also want to attack unacceptable sequences from the EDA automation side (automatic sequence constraints)	Steve email 9/29/00	

5.1.1.2 En Route Spacing

Number	Requirement Statement	Verbatim Statement	Source Document	Section
ES-1	EDA shall support the controller in planning and implementing fuel-efficient clearances for conformance to en route spacing constraints	▪ the flow-rate conformance capabilities (for arrival metering or en route spacing) allow the controller to plan and implement fuel-efficient clearances for conformance. ▪ EDA provides fuel-efficient advisories for flow-rate conformance and integrates those advisories with conflict detection and resolution (CD&R) capabilities. ▪ DA also generates clearance advisories based on fuel-efficient Descent Profiles.	Milestone 5.10 Milestone 5.10 CSC DA FD 5/98	Sec 3.1.1 Sec 1.1 Sec 3.8.2

ES-2	EDA shall provide active flow-rate conformance advisories for en route spacing	▪ Trajectory-oriented solutions are enabled by providing controllers with active flow-rate-conformance advisories (integrated with CD&R capabilities) and accurate 4D-trajectory predictions. ▪ These functions generate the EDA advisories for flow-rate conformance. ▪ Build 3 will include flow-conformance advisories, integrated CD/R with resolution advisories for metered and non-metered flights, automation for inter-sector coordination, fast controller inputs and provisional planning, and some limited integration of experimental communication, navigation, surveillance (CNS) capabilities	Milestone 5.10 Milestone 5.10 TO45 SOW	Sec 4.0 Sec 4.2 Sec I
ES-3	EDA spacing clearances shall be integrated with CD&R (separation assurance)	▪ Trajectory-oriented solutions are enabled by providing controllers with active flow-rate-conformance advisories (integrated with CD&R capabilities) and accurate 4D-trajectory predictions. ▪ Build 3 will include flow-conformance advisories, integrated CD/R with resolution advisories for metered and non-metered flights, automation for inter-sector coordination, fast controller inputs and provisional planning, and some limited integration of experimental communication, navigation, surveillance (CNS) capabilities	Milestone 5.10 TO45 SOW	Sec 4.0 Sec I
ES-4	EDA shall assist the controller with the planning of delay maneuvers for spacing	▪ ATC automation tools assist the controller with the planning of delay maneuvers	Milestone 5.10	Sec 2.1
ES-5	EDA shall assist the controller in selecting the most efficient delay absorption techniques	▪ This automation would enable controllers to select more efficient delay absorption techniques (e.g., speed reduction) and begin delay actions earlier with smaller deviations.	Milestone 5.10	Sec 2.1
ES-6	EDA shall provide "active" meet-time (-spacing)	• "Active" meet-time advisories for fuel-efficient conformance to flow-rate constraints	Milestone 5.10 Milestone 5.10	Sec 3.0 Sec 4.0

	advisories for fuel-efficient conformance to spacing constraints	(i.e., arrival metering or spacing) ▪ Trajectory-oriented solutions are enabled by providing controllers with active flow-rate-conformance advisories (integrated with CD&R capabilities) and accurate 4D-trajectory predictions.		
ES-7	EDA shall detect flow-rate conformance problems up to 20 minutes in the future (1-2 sectors)	• EDA will accurately detect separation and flow-rate conformance problems up to 20 minutes into the future (generally across 1-2 sectors).	RTO34B	Sec 2
ES-8	EDA shall integrate spacing conformance advisories with conflict detection and resolution	▪ EDA provides fuel-efficient advisories for flow-rate conformance and integrates those advisories with conflict detection and resolution (CD&R) capabilities. ▪ integrates those advisories with conflict detection and resolution (CD&R) capabilities ▪ it is necessary to integrate DST capabilities for flow-rate conformance and conflict detection and resolution (CD&R) ▪ Integration of flow-rate-conformance advisories with CD&R to reduce controller workload in the planning, monitoring, and conformance of flow-rate restrictions and separation assurance. ▪ The development of DST capabilities for "strategic" flow-rate conformance, and their integration with CD&R capabilities, will minimize ATC interruptions. ▪ Trajectory-oriented solutions are enabled by providing controllers with active flow-rate-conformance advisories (integrated with CD&R capabilities) and accurate 4D-trajectory predictions. ▪ The piece de resistance of EDA is the integration of CD&R and flow-rate conformance capabilities.	Milestone 5.10 Milestone 5.10 Milestone 5.10 Milestone 5.10 Milestone 5.10 Milestone 5.10 Milestone 5.10 Milestone 5.10	Sec 1.1 Sec 1.1 Sec 2.0 Sec 3.0 Sec 3.1.3 Sec 4.0 Sec 4.2 Sec 4.2

		▪ the EDA technology concept emphasizes two key aspects: a flexible suite of advisory capabilities; and integration of CD&R and flow-rate conformance advisories.		
ES-9	EDA shall provide planning, monitoring, and conformance tracking of spacing constraints	▪ integrates those advisories with conflict detection and resolution (CD&R) capabilities ▪ it is necessary to integrate DST capabilities for flow-rate conformance and conflict detection and resolution (CD&R) ▪ Integration of flow-rate-conformance advisories with CD&R to reduce controller workload in the planning, monitoring, and conformance of flow-rate restrictions and separation assurance. ▪ The development of DST capabilities for "strategic" flow-rate conformance, and their integration with CD&R capabilities, will minimize ATC interruptions. ▪ Trajectory-oriented solutions are enabled by providing controllers with active flow-rate-conformance advisories (integrated with CD&R capabilities) and accurate 4D-trajectory predictions. ▪ The piece de resistance of EDA is the integration of CD&R and flow-rate conformance capabilities.	Milestone 5.10 Milestone 5.10 Milestone 5.10 Milestone 5.10 Milestone 5.10 Milestone 5.10	Sec 1.1 Sec 2.0 Sec 3.0 Sec 3.1.3 Sec 4.0 Sec 4.2
ES-10	EDA shall provide "strategically-accurate" flow rate conformance advisories: advising a plan that is nominally in conformance rather than dividing up the responsibility over space and time	▪ The development of DST capabilities for "strategic" flow-rate conformance, and their integration with CD&R capabilities, will minimize ATC interruptions. ▪ Trajectory-oriented solutions are enabled by providing controllers with active flow-rate-conformance advisories (integrated with CD&R capabilities) and accurate 4D-trajectory predictions.	Milestone 5.10 Milestone 5.10	Sec 3.1.3 Sec 4.0
ES-11	Spacing conformance detection and resolution	▪ Conflict detection/resolution capabilities and	RTO34B	Sec 8.2

	shall be fully configurable by controllers so that preferences can be set and saved.	the associated interfaces should be fully configurable by the controller so that preferences can be set and saved. Some examples of preferences that controllers requested: • Detection time horizon for conflicts should be adjustable in the range of 5-20 min • Detection time horizon for flow-rate conformance problems should be adjustable in the range of 5-20 min • Resolution time horizon for conflicts should be adjustable in the range of 5-20 min • Resolution time horizon for flow-rate conformance problems should be adjustable in the range of 5-20 min • Separation minima that will signal an alert should be adjustable in the range of 5-15 nm		
ES-12	Spacing preferences shall include time horizon for conformance problem detection (5-20 min) and resolution (5-20 min)	▪ Conflict detection/resolution capabilities and the associated interfaces should be fully configurable by the controller so that preferences can be set and saved. Some examples of preferences that controllers requested: • Detection time horizon for conflicts should be adjustable in the range of 5-20 min • Detection time horizon for flow-rate conformance problems should be adjustable in the range of 5-20 min • Resolution time horizon for conflicts should be adjustable in the range of 5-20 min • Resolution time horizon for flow-rate conformance problems should be adjustable in the range of 5-20 min	RTO34B	Sec 8.2

		• Separation minima that will signal an alert should be adjustable in the range of 5-15 nm		
ES-13	Advisories are determined by iterating on degrees of freedom (DOF) to meet spacing constraints	• Advisories are determined by iterating on “degrees-of-freedom” (DOFs) and attempt to meet traffic management constraints such as TMA-generated meter-fix STAs.	CSC DA FD 5/98	Sec 3
ES-14	Advisories are compliant with crossing restrictions and similar to those generated for advanced onboard Flight Management Systems (FMS)	• Advisories are compliant with MF Crossing Restrictions and similar to those generated from advanced onboard Flight Management Systems (FMS).	CSC DA FD 5/98	Sec 3
ES-15	EDA shall provide the controller with an estimation of separation between aircraft arriving at a future merge point	• The Spacing Tool provides the controller with an estimation of separation between aircraft arriving at a future merge point.	CSC DA FD 5/98	Sec 3.4
ES-16	EDA flow conformance functionality shall be configurable by controllers	• Controllers can tailor the operational characteristics of DA.	CSC DA FD 5/98	Sec 3.8.1
ES-17	EDA shall allow the definition of an arbitrary location in space to be used as reference for spacing calculations	• [the current software] must be modified to allow any waypoint (a la auxiliary waypoint) to be used [for the reference fix for MIT/spacing]	Steve email 1/14/98	
ES-18	EDA shall support multiple streams of traffic for spacing based on unique reference fixes and/or altitudes	• [we need the following enhancements:] multiple streams based on different reference fixes and/or altitudes	Steve email 1/14/98	
ES-19	EDA shall automatically identify information for streams of traffic (ID aircraft, ID reference fix, etc.) given general information from the controllers	• [we need the following enhancements:] automation to help select the streams (ID aircraft, select the fix, …)	Steve email 1/14/98	
ES-20	EDA shall support the coordination of spacing streams among sector controller teams	• There is a further issue for intersector coordination of [spacing] streams	Steve email 1/14/98	
ES-21	EDA shall maximize FMS utilization	• [EDA functions:] efficient descent planning,	Steve email	

		clearance advisory and monitoring - compatible with airborne FMS-LNAV/VNAV (maximizes FMS utilization)	1/14/98	
ES-22	EDA shall provide mile-in-trail constraint spacing feedback	• [EDA functions:] integration of cruise and descent planning, with applicable traffic management constraints - metering fix spacing feedback for use with miles-in-trail constraints	Steve email 1/14/98	
ES-23	EDA shall provide spacing advisories shall support en route and metering fix constraints for aircraft on different flight paths	• [EDA functions:] spacing feedback that supports management of miles-int-trail constraints (both en route and metering fix) for aircraft on different flight paths	Steve email 1/14/98	

5.1.1.3 Active Advisory Generation for Flow Conformance

Number	Requirement Statement	Verbatim Statement	Source Document	Section
AG-1	EDA shall provide cruise and descent speed advisories	▪ the controller may have selected an automatic cruise/descent-speed advisory for metering, but wishes to manually adjust the descent speed (e.g., trial plan) for conflict resolution. ▪ DA provides the controller with descent advisories that they can use as a basis for issuing ATC clearance advisories.	Milestone 5.10 CSC DA FD 5/98	Sec 4.1 Sec 3
AG-2	EDA shall provide three speed profile advisory modes: Cruise-only; Descent-only; and Cruise-Plus-Descent	▪ Speed profile advisories may be generated in three modes: Cruise-only; Descent-only; and Cruise-Plus-Descent. ▪ In Cruise-only, EDA iterates within the aircraft's cruise-speed envelope to determine a new cruise speed to meet the time at a meter fix. ▪ In Descent-only, EDA iterates within the	Milestone 5.10 Milestone 5.10 Milestone 5.10 Milestone 5.10	Sec 4.2 Sec 4.2 Sec 4.2 Sec 4.2

		descent-speed envelope to determine a descent-speed profile (Mach/KIAS) to meet the time. ▪ In Cruise-Plus-Descent, EDA iterates on both descent and cruise-speed profiles.		
AG-3	Cruise-only mode shall iterate within the aircraft's cruise speed envelope to determine a new cruise speed to meet the flow conformance constraint	▪ In Cruise-only, EDA iterates within the aircraft's cruise-speed envelope to determine a new cruise speed to meet the time at a meter fix.	Milestone 5.10	Sec 4.2
AG-4	Descent-only mode shall iterate within the aircraft's descent speed envelope to determine a descent-speed profile (Mach/KIAS) to meet the flow conformance constraint	▪ In Descent-only, EDA iterates within the descent-speed envelope to determine a descent-speed profile (Mach/KIAS) to meet the time. ▪ In general, CAS and Mach are the DOFs used internally by the TS, however, Cruise Altitude and "path distance" can also be utilized when using TS to solve for a DA trajectory ▪ Since pilots can fly their aircraft at a fixed speed (CAS or Mach) and altitude, Cruise CAS, Cruise Altitude, Descent CAS and Descent Mach are the variables that DA has been designed to use as DOFs for time control. ▪ DA can also vary the Descent Profile type and in a broad sense, the DA algorithm uses the Descent Profile as DOF.	Milestone 5.10 CSC DA FD 5/98 CSC DA FD 5/98 CSC DA FD 5/98	Sec 4.2 Sec 3.6 Sec 3.6 Sec 3.6
AG-5	Cruise-Plus-Descent mode shall iterate on both descent- and cruise-speed profiles to meet the flow conformance constraint	▪ In Cruise-Plus-Descent, EDA iterates on both descent and cruise-speed profiles.	Milestone 5.10	Sec 4.2
AG-6	EDA shall generate top-of-descent (TOD) advisories and descent profiles as a function of selected speed profile, 3D crossing restriction, aircraft performance; and atmospheric state	▪ Top-of-descent (TOD) advisories and descent profile are generated as a function of the selected speed profile, 3D crossing restriction (altitude and speed at a fix), aircraft performance (thrust/drag model and weight), and atmospheric state (predicted winds and temperature aloft).	Milestone 5.10	Sec 4.2

AG-7	EDA shall generate new cruise-altitude advisories to meet flow conformance constraints	▪ New cruise-altitude advisories are also computed to help meet a time at a meter fix. ▪ In general, CAS and Mach are the DOFs used internally by the TS, however, Cruise Altitude and "path distance" can also be utilized when using TS to solve for a DA trajectory	Milestone 5.10 CSC DA FD 5/98	Sec 4.2 Sec 3.6
AG-8	EDA shall generate path-stretch (PS) advisories as its primary lateral-profile advisory for flow rate conformance	• The primary lateral-profile advisory mode for flow-rate conformance is the Path-stretch mode (PS). ▪ The primary lateral-profile advisory mode for flow-rate conformance is the Path-stretch mode (PS). ▪ EDA meets the time by iterating on the range to fly (along a controller-defined vector) before the flight is returned to its route at a controller-defined capture waypoint. ▪ In general, CAS and Mach are the DOFs used internally by the TS, however, Cruise Altitude and "path distance" can also be utilized when using TS to solve for a DA trajectory	Milestone 5.10 Milestone 5.10 Milestone 5.10 CSC DA FD 5/98	Sec 4.2 Sec 4.2 Sec 4.2 Sec 3.6
AG-9	PS mode shall iterate on the range to fly along a controller defined vector before the flight is returned to its route at a controller defined capture waypoint	▪ EDA meets the time by iterating on the range to fly (along a controller-defined vector) before the flight is returned to its route at a controller-defined capture waypoint. ▪ The PS [path stretch] advisories apply to aircraft in PS and pertain to the aircraft's Turnout and Turnback maneuvers. ▪ PS uses "path distance" as a DOF and can absorb relatively large time delays that are beyond the scope of iterations on other DOFs. ▪ PS uses the Capture Waypoint as the endpoint of the PS portion of the trajectory. ▪ Another DOF that DA may use is path distance. ▪ pilots can be instructed to turnout away from a direct heading to a fix for a period and later	Milestone 5.10 CSC DA FD 5/98 CSC DA FD 5/98 CSC DA FD 5/98 CSC DA FD 5/98 CSC DA FD 5/98 CSC DA FD 5/98 CSC DA FD 5/98	Sec 4.2 Sec 3.3 Sec 3.3 Sec 3.3 Sec 3.6 Sec 3.6 Sec 3.6 Sec 3.8.1

		instructed to turnback to a direct heading to that fix. [PS] ▪ When the PS feature in DA is applied to an aircraft, DA uses path distance along the PS maneuvers as a DOF. ▪ The PS feature in DA helps controllers use PS by providing them with advisories for the PS Turnout and Turnback maneuvers.		
AG-10	EDA shall provide a manual version of PS mode called "Delay Countdown" (DC) mode	▪ The manual version of the PS mode is referred to as "Delay Countdown" (DC). In this mode, EDA provides the controller with feedback on the state of each flight, the DC advisory indicates the delay remaining to be absorbed.	Milestone 5.10	Sec 4.2
AG-11	DC mode shall provide feedback on the state of each flight, indicating delay remaining to be absorbed	▪ The manual version of the PS mode is referred to as "Delay Countdown" (DC). In this mode, EDA provides the controller with feedback on the state of each flight, the DC advisory indicates the delay remaining to be absorbed.	Milestone 5.10	Sec 4.2
AG-12	EDA shall cue the controller to laterally expedite a flight if flow conformance constraints (i.e., metering delays or spacing) can be reduced	▪ If metering delays may be reduced by expediting a flight (i.e., taking a more direct route to the meter fix), EDA will cue the controller to do so.	Milestone 5.10	Sec 4.2
AG-13	EDA shall provide flexible advisory capabilities for flow rate conformance	• the EDA technology concept emphasizes two key aspects: a flexible suite of advisory capabilities; and integration of CD&R and flow-rate conformance advisories.	Milestone 5.10	Sec 4.2
AG-14	DC mode shall provide identical delay feedback a provided by basic TMA metering (albeit at a much lower level of accuracy)	▪ In its simplest form, the DC mode is identical to the delay feedback provided by basic TMA metering (albeit at a much lower level of accuracy).	Milestone 5.10	Sec 4.2
AG-15	Advisories are calculated for arrival aircraft from their top-of-ascent (TOA) positions to their metering fixes	• These [descent] advisories are calculated for arrival aircraft from their Top-Of-Ascent (TOA) positions to their Meter Fixes (MF).	CSC DA FD 5/98 CSC DA FD 5/98	Sec 3 Sec 3.1

		• These cruise advisories provide controllers with information necessary to issue clearances for aircraft prior to reaching their TOD positions.		
AG-16	Cruise advisories pertain to the speed (cruise speed advisory) and altitude (new cruise altitude advisory) of the aircraft between TOA and TOD	• The Cruise advisory pertains to the speed and altitude of the aircraft while it is on the portion of its projected trajectory between its TOA and TOD positions. • The two parts of the Cruise advisory are Cruise Speed and Cruise Altitude. • Since pilots can fly their aircraft at a fixed speed (CAS or Mach) and altitude, Cruise CAS, Cruise Altitude, Descent CAS and Descent Mach are the variables that DA has been designed to use as DOFs for time control.	CSC DA FD 5/98 CSC DA FD 5/98 CSC DA FD 5/98	Sec 3.1 Sec 3.1 Sec 3.6
AG-17	Descent profile advisories pertain to the vertical profile of the aircraft between the TOD and metering fix	• The Descent Profile advisory pertains to the vertical profile that a pilot can be instructed to follow while on the portion of their aircraft's projected trajectory between the aircraft's TOD position and the MF. • The Descent Profile pertains to the vertical profile of an aircraft from its TOD position to its MF.	CSC DA FD 5/98 CSC DA FD 5/98	Sec 3.2 Sec 3.7
AG-18	EDA shall use the company preferred descent profile, unless required to change based on constraints	• DA always attempts to use the Descent CAS specified by the Company Preferred Descent Profile • DA also allows airlines to define their Company Preferred Descent Profile and will use it for the post-TOD portion of flight unless the STA can not be met	CSC DA FD 5/98 CSC DA FD 5/98	Sec 3.7 Sec 3.8.2

AG-19	Descent profiles shall minimize powered flight at low altitude and permit idle thrust descents	• The DA algorithm ensures that the Descent Profile is optimally fuel-efficient by first choosing a TOD point so as to minimize powered flight at low altitude and second by generating altitude-speed profiles that permit idle thrust flight throughout the descent.	CSC DA FD 5/98	Sec 3.8.2
AG-20	EDA shall provide continuous updates of clearance advisories	• [EDA system capabilities:] continuous update of trajectory predictions/clearance advisories to reflect changes in aircraft state, atmospheric predictions, and intent of the pilot and controller	Steve email 1/14/98	

5.1.2 Trajectory Generation

Number	Requirement Statement	Verbatim Statement	Source Document	Section
TG-1	EDA shall provide accurate 4D trajectory predictions	▪ Trajectory-oriented solutions are enabled by providing controllers with active flow-rate-conformance advisories (integrated with CD&R capabilities) and accurate 4D-trajectory predictions. • "Seconds" accuracy in 4D prediction to reduce excess buffers and conservative constraints. • the 4D accuracy of the EDA advisories and predictions will reduce the extent and impact of flow-rate restrictions • the EDA accuracy will reduce the need for static lateral restrictions, prior to the TRACON, and result in greater user flexibility and flight efficiency. • the 4D accuracy will also reduce the need for static lateral restrictions at the TRACON boundary	Milestone 5.10 Milestone 5.10 Milestone 5.10 Milestone 5.10 Milestone 5.10 Milestone 5.10 Milestone 5.10 CSC DA FD 5/98	Sec 4.0 Sec 3.0 Sec 3.1.1 Sec 3.1.2 Sec 3.1.2 Sec 4.1 Sec 4.1 Sec 3.5

		• The foundation of EDA is accurate 4D-trajectory predictions. ▪ The approach used by EDA is to integrate the point-mass model kinetic equations of motion based on first principles. ▪ The essential ingredient in DA's ability to provide time-control is accurate prediction of aircraft trajectories.		
TG-2	EDA shall predict trajectories 20 minutes into the future	• Accurately predicting trajectories 20 minutes into the future requires unique DST capabilities.	RTO34B	Sec 8
TG-3	EDA shall provide "seconds" accuracy in trajectory predictions	• "Seconds" accuracy in 4D prediction to reduce excess buffers and conservative constraints. • the 4D accuracy of the EDA advisories and predictions will reduce the extent and impact of flow-rate restrictions • the EDA accuracy will reduce the need for static lateral restrictions, prior to the TRACON, and result in greater user flexibility and flight efficiency. • the 4D accuracy will also reduce the need for static lateral restrictions at the TRACON boundary • The foundation of EDA is accurate 4D-trajectory predictions. • The approach used by EDA is to integrate the point-mass model kinetic equations of motion based on first principles.	Milestone 5.10 Milestone 5.10 Milestone 5.10 Milestone 5.10 Milestone 5.10 Milestone 5.10	Sec 3.0 Sec 3.1.1 Sec 3.1.2 Sec 3.1.2 Sec 4.1 Sec 4.1
TG-4	EDA trajectory prediction shall support the removal of static lateral restrictions prior to the TRACON and at the TRACON boundary	• the EDA accuracy will reduce the need for static lateral restrictions, prior to the TRACON, and result in greater user flexibility and flight efficiency. • the 4D accuracy will also reduce the need for static lateral restrictions at the TRACON boundary	Milestone 5.10 Milestone 5.10	Sec 3.1.2 Sec 3.1.2

TG-5	EDA trajectory prediction shall integrate point-mass model kinetic equations of motion based on first principals (three translational dimensions plus roll)	• The approach used by EDA is to integrate the point-mass model kinetic equations of motion based on first principles.	Milestone 5.10	Sec 4.1
TG-6	EDA shall support two primary navigation modes – Route Intercept (RI) and Waypoint Capture (WC)	▪ The two primary modes are Route Intercept (RI) and Waypoint Capture (WC). ▪ The RI mode determines the future path based on a flight's current state (position and velocity), the flight plan route, and any ATSP-defined route structures (e.g., STARs). ▪ The WC mode determines the future path based on a flight's current state (position and velocity), a controller-defined "capture" waypoint, the flight plan route, and any ATSP-defined route structures (e.g., STARs).	Milestone 5.10 Milestone 5.10 Milestone 5.10	Sec 4.2 Sec 4.2 Sec 4.2
TG-7	RI mode shall determine future path based on the flight's current state, flight plan route, and any ATSP-defined route structures (e.g., STARS)	▪ The RI mode determines the future path based on a flight's current state (position and velocity), the flight plan route, and any ATSP-defined route structures (e.g., STARs).	Milestone 5.10	Sec 4.2
TG-8	WC mode shall determine future path based on the flight's current state, a controller defined "capture" waypoint, the flight plan route, and any ATSP-defined route structures (e.g., STARS)	▪ The WC mode determines the future path based on a flight's current state (position and velocity), a controller-defined "capture" waypoint, the flight plan route, and any ATSP-defined route structures (e.g., STARs).	Milestone 5.10	Sec 4.2
TG-9	EDA shall generate S-turns trajectories for a prescribed amount of time	▪ All the commonly used actions by controllers and pilots that result in changes to the nominal flight plan would be entered into the system through easily accessed interface entry options. Examples of intent choices (e.g., via a pull-down menu) are listed below: • "Direct to" – allows aircraft to fly from current position to a downstream fix, airport, etc. • Path-stretch/S-turns – allows aircraft to fly prescribed maneuver for prescribed time. • Air hold – allows aircraft to be place into a	RTO34B	Sec 8.1

		holding pattern at the current location. This would effectively "pause" the trajectory synthesis predictions until the aircraft was released from the hold. An alert of a potential conflict should be signaled for any other aircraft that is predicted to pass near the oval-shaped airspace of the holding aircraft • Release air hold – allows aircraft to be released from hold and resume original flight plan • Change in airway – allows aircraft to switch from current airway to another airway at the next shared intersection • Ignore crossing restriction – allows aircraft to maintain current speed/altitude despite an active crossing restriction requirement that is in effect. • Modify crossing restriction – allows aircraft to meet a modified crossing restriction requirement (e.g., meets the nominal altitude, but at a faster speed) • Climb/descend immediately – allows aircraft to climb/descend to specified altitude • Climb/descend at specified fix – allows aircraft to climb/descend to specified altitude at specified fix • Increase/reduce speed immediately – allows aircraft to immediately increase/reduce speed as specified		
TG-10	EDA shall generate holding patterns by pausing trajectory synthesis prediction until after the aircraft is released from the holding pattern	▪ All the commonly used actions by controllers and pilots that result in changes to the nominal flight plan would be entered into the system through easily accessed interface entry options. Examples of intent choices (e.g., via	RTO34B	Sec 8.1

		a pull-down menu) are listed below: • "Direct to" – allows aircraft to fly from current position to a downstream fix, airport, etc. • Path-stretch/S-turns – allows aircraft to fly prescribed maneuver for prescribed time. • Air hold – allows aircraft to be place into a holding pattern at the current location. This would effectively "pause" the trajectory synthesis predictions until the aircraft was released from the hold. An alert of a potential conflict should be signaled for any other aircraft that is predicted to pass near the oval-shaped airspace of the holding aircraft • Release air hold – allows aircraft to be released from hold and resume original flight plan • Change in airway – allows aircraft to switch from current airway to another airway at the next shared intersection • Ignore crossing restriction – allows aircraft to maintain current speed/altitude despite an active crossing restriction requirement that is in effect. • Modify crossing restriction – allows aircraft to meet a modified crossing restriction requirement (e.g., meets the nominal altitude, but at a faster speed) • Climb/descend immediately – allows aircraft to climb/descend to specified altitude • Climb/descend at specified fix – allows aircraft to climb/descend to specified altitude at specified fix • Increase/reduce speed immediately –		

		allows aircraft to immediately increase/reduce speed as specified		
TG-11	EDA trajectory generation shall use the same approach as that by FMS systems	▪ EDA utilizes the same approach as used by flight management system (FMS) algorithms. One feature of FMS is to maximizes the use of the speed envelope for maintaining required times of arrivals. ▪ DA computes a Descent Profile similar to those computed by onboard FMS systems. ▪ [EDA functions:] efficient descent planning, clearance advisory and monitoring - compatible with airborne FMS-LNAV/VNAV (maximizes FMS utilization)	RTO34B CSC DA FD 5/98 Steve email 1/14/98	Sec 5.5 Sec 3.8.3
TG-12	EDA shall account for the thrust and drag characteristics of each aircraft type	▪ However, the EDA trajectory-integration process also accounts directly for the thrust and drag models of each aircraft type ▪ This algorithm generates an FMS-like 4D trajectory using detailed models of aircraft performance, pilot procedures, operator preferences, flight plan (FP) information, and accurate weather and track data	Milestone 5.10 CSC DA FD 5/98	Sec 4.1 Sec 3.5
TG-13	EDA shall model the effect of speed profile and wind gradient on vertical rate	▪ EDA models the affect of speed profile and wind gradient on the vertical rate ▪ This algorithm generates an FMS-like 4D trajectory using detailed models of aircraft performance, pilot procedures, operator preferences, flight plan (FP) information, and accurate weather and track data	Milestone 5.10 CSC DA FD 5/98	Sec 4.1 Sec 3.5
TG-14	EDA shall model pilot procedures and operator preferences during trajectory prediction	• This algorithm generates an FMS-like 4D trajectory using detailed models of aircraft performance, pilot procedures, operator preferences, flight plan (FP) information, and accurate weather and track data	CSC DA FD 5/98	Sec 3.5
TG-15	EDA shall be able to generate trajectories using time as an independent variable to meet STA	• TS has the ability to treat time as an independent variable and determine time-	CSC DA FD 5/98	Sec 3.5

	restrictions	specified trajectories to meet STAs.		
TG-16	EDA shall provide trajectories with arrival time prediction accuracy [cumulative prediction accuracy over length of trajectory) to 20 seconds or less	• The goal for DA is to reduce arrival time prediction error [cumulative prediction error over an entire trajectory] to 20 seconds or less	CSC DA FD 5/98	Sec 3.5
TG-17	EDA shall allow the definition of an arbitrary location in space as a waypoint for trajectory generation of later paths [auxiliary waypoint]	• [the current software] must be modified to allow any waypoint (a la auxiliary waypoint) to be used [for the reference fix for MIT/spacing]	Steve email 1/14/98	
TG-18	EDA shall provide continuous updates of trajectory predictions	• [EDA system capabilities:] continuous update of trajectory predictions/clearance advisories to reflect changes in aircraft state, atmospheric predictions, and intent of the pilot and controller	Steve email 1/14/98	
TG-19	EDA shall support both standard (jet and victor routes, NAVAIDS) and non-standard (NRP routes, free vectors, direct and best-wind routes)	• [EDA system capabilities:] support both standard (jet and victor routes, NAVAIDS) and non-standard (NRP routes, free vectors, direct and best-wind routes)	Steve email 1/14/98	

5.1.3 Separation Assurance

5.1.3.1 Conflict Detection

Number	Requirement Statement	Verbatim Statement	Source Document	Section
CD-1	EDA shall assist controllers in the detection of aircraft separation assurance problems	▪ to assist controllers to enable … separation	Milestone 5.10	Sec 1.1
CD-2	EDA shall detect separation assurance problems up to 20 minutes in the future (1-2 sectors)	• EDA will accurately detect separation and flow-rate conformance problems up to 20 minutes into the future (generally across 1-2	RTO34B	Sec 2

		sectors).		
CD-3	EDA shall integrate conflict detection with flow conformance advisories (metering and en route spacing)	▪ EDA provides fuel-efficient advisories for flow-rate conformance and integrates those advisories with conflict detection and resolution (CD&R) capabilities. ▪ integrates those advisories with conflict and resolution (CD&R) capabilities ▪ it is necessary to integrate DST capabilities for flow-rate conformance and conflict detection and resolution (CD&R) ▪ Integration of flow-rate-conformance advisories with CD&R to reduce controller workload in the planning, monitoring, and conformance of flow-rate restrictions and separation assurance. ▪ The development of DST capabilities for "strategic" flow-rate conformance, and their integration with CD&R capabilities, will minimize ATC interruptions. ▪ Trajectory-oriented solutions are enabled by providing controllers with active flow-rate-conformance advisories (integrated with CD&R capabilities) and accurate 4D-trajectory predictions. ▪ The piece de resistance of EDA is the integration of CD&R and flow-rate conformance capabilities. ▪ the EDA technology concept emphasizes two key aspects: a flexible suite of advisory capabilities; and integration of CD&R and flow-rate conformance advisories. ▪ Build 3 will include flow-conformance advisories, integrated CD/R with resolution advisories for metered and non-metered flights, automation for inter-sector coordination, fast controller inputs and	Milestone 5.10 Milestone 5.10 Milestone 5.10 Milestone 5.10 Milestone 5.10 Milestone 5.10 Milestone 5.10 Milestone 5.10 TO45 SOW	Sec 1.1 Sec 1.1 Sec 2.0 Sec 3.0 Sec 3.1.3 Sec 4.0 Sec 4.2 Sec 4.2 Sec I

		provisional planning, and some limited integration of experimental communication, navigation, surveillance (CNS) capabilities		
CD-4	EDA shall provide planning, monitoring, and conformance tracking of separation assurance constraints	▪ integrates those advisories with conflict detection and resolution (CD&R) capabilities ▪ it is necessary to integrate DST capabilities for flow-rate conformance and conflict detection and resolution (CD&R) ▪ Integration of flow-rate-conformance advisories with CD&R to reduce controller workload in the planning, monitoring, and conformance of flow-rate restrictions and separation assurance. ▪ The development of DST capabilities for "strategic" flow-rate conformance, and their integration with CD&R capabilities, will minimize ATC interruptions. ▪ Trajectory-oriented solutions are enabled by providing controllers with active flow-rate-conformance advisories (integrated with CD&R capabilities) and accurate 4D-trajectory predictions. ▪ The piece de resistance of EDA is the integration of CD&R and flow-rate conformance capabilities.	Milestone 5.10 Milestone 5.10 Milestone 5.10 Milestone 5.10 Milestone 5.10 Milestone 5.10	Sec 1.1 Sec 2.0 Sec 3.0 Sec 3.1.3 Sec 4.0 Sec 4.2
CD-5	EDA shall support distributed air/ground separation assurance	▪ Fourth, trajectory orientation is a critical enabler for the Free Flight concept, particularly the DAG-TM concepts related to trajectory negotiation or distributed air-ground separation assurance. ▪ Active plans are particularly critical to the configuration management for distributed air-ground (user-ATM) trajectory planning such as trajectory negotiation or airborne free maneuvering	Milestone 5.10 Milestone 5.10	Sec 2.2.2 Sec 4.1
CD-6	EDA shall provide conflict detection for holding	▪ All the commonly used actions by controllers	RTO34B	Sec 8.1

	patterns by signaling potential conflict when an aircraft is predicted to pass near the oval-shaped airspace of the holding aircraft	and pilots that result in changes to the nominal flight plan would be entered into the system through easily accessed interface entry options. Examples of intent choices (e.g., via a pull-down menu) are listed below: • "Direct to" – allows aircraft to fly from current position to a downstream fix, airport, etc. • Path-stretch/S-turns – allows aircraft to fly prescribed maneuver for prescribed time. • Air hold – allows aircraft to be place into a holding pattern at the current location. This would effectively "pause" the trajectory synthesis predictions until the aircraft was released from the hold. An alert of a potential conflict should be signaled for any other aircraft that is predicted to pass near the oval-shaped airspace of the holding aircraft • Release air hold – allows aircraft to be released from hold and resume original flight plan • Change in airway – allows aircraft to switch from current airway to another airway at the next shared intersection • Ignore crossing restriction – allows aircraft to maintain current speed/altitude despite an active crossing restriction requirement that is in effect. • Modify crossing restriction – allows aircraft to meet a modified crossing restriction requirement (e.g., meets the nominal altitude, but at a faster speed) • Climb/descend immediately – allows aircraft to climb/descend to specified altitude		

		• Climb/descend at specified fix – allows aircraft to climb/descend to specified altitude at specified fix • Increase/reduce speed immediately – allows aircraft to immediately increase/reduce speed as specified		
CD-7	CD shall be fully configurable by controllers so that preferences can be set and saved.	▪ Conflict detection/resolution capabilities and the associated interfaces should be fully configurable by the controller so that preferences can be set and saved. Some examples of preferences that controllers requested: • Detection time horizon for conflicts should be adjustable in the range of 5-20 min • Detection time horizon for flow-rate conformance problems should be adjustable in the range of 5-20 min • Resolution time horizon for conflicts should be adjustable in the range of 5-20 min • Resolution time horizon for flow-rate conformance problems should be adjustable in the range of 5-20 min • Separation minima that will signal an alert should be adjustable in the range of 5-15 nm • Controllers can tailor the operational characteristics of DA.	RTO34B CSC DA FD 5/98	Sec 8.2 Sec 3.8.1
CD-8	CD preferences shall include time horizon for detection (5-20 min) and separation minima (5-15 nmi)	▪ Conflict detection/resolution capabilities and the associated interfaces should be fully configurable by the controller so that preferences can be set and saved. Some examples of preferences that controllers requested: • Detection time horizon for conflicts should be adjustable in the range of 5-20 min	RTO34B	Sec 8.2

		• Detection time horizon for flow-rate conformance problems should be adjustable in the range of 5-20 min • Resolution time horizon for conflicts should be adjustable in the range of 5-20 min • Resolution time horizon for flow-rate conformance problems should be adjustable in the range of 5-20 min • Separation minima that will signal an alert should be adjustable in the range of 5-15 nm		
CD-9	CD shall support metered and non-metered flights	• Build 3 will include flow-conformance advisories, integrated CD/R with resolution advisories for metered and non-metered flights, automation for inter-sector coordination, fast controller inputs and provisional planning, and some limited integration of experimental communication, navigation, surveillance (CNS) capabilities	TO45 SOW	Sec I
ES-24	EDA shall provide multi-aircraft minimum separation feedback to identify dynamic “choke points” for streams of aircraft on non-standard routes	• [EDA functions:] multi-aircraft minimum separation feedback to identify dynamic "choke points" for streams of aircraft on non-standard routes	Steve email 1/14/98	

5.1.3.2 Conflict Resolution

Number	Requirement Statement	Verbatim Statement	Source Document	Section
CR-1	EDA shall assist controllers in the resolution of aircraft separation assurance problems	▪ EDA provides fuel-efficient advisories for flow-rate conformance and integrates those advisories with conflict detection and resolution (CD&R) capabilities.	Milestone 5.10	Sec 1.1
CR-2	EDA shall integrate conflict resolution with flow conformance advisories (metering and en route	▪ EDA provides fuel-efficient advisories for flow-rate conformance and integrates those	Milestone 5.10 Milestone 5.10	Sec 1.1 Sec 1.1

	spacing)	advisories with conflict detection and resolution (CD&R) capabilities. ▪ integrates those advisories with conflict detection and resolution (CD&R) capabilities ▪ it is necessary to integrate DST capabilities for flow-rate conformance and conflict detection and resolution (CD&R) ▪ Integration of flow-rate-conformance advisories with CD&R to reduce controller workload in the planning, monitoring, and conformance of flow-rate restrictions and separation assurance. ▪ The development of DST capabilities for "strategic" flow-rate conformance, and their integration with CD&R capabilities, will minimize ATC interruptions. ▪ Trajectory-oriented solutions are enabled by providing controllers with active flow-rate-conformance advisories (integrated with CD&R capabilities) and accurate 4D-trajectory predictions. ▪ The piece de resistance of EDA is the integration of CD&R and flow-rate conformance capabilities. ▪ the EDA technology concept emphasizes two key aspects: a flexible suite of advisory capabilities; and integration of CD&R and flow-rate conformance advisories. ▪ Build 3 will include flow-conformance advisories, integrated CD/R with resolution advisories for metered and non-metered flights, automation for inter-sector coordination, fast controller inputs and provisional planning, and some limited integration of experimental communication, navigation, surveillance (CNS) capabilities	Milestone 5.10 Milestone 5.10 Milestone 5.10 Milestone 5.10 Milestone 5.10 Milestone 5.10 TO45 SOW	Sec 2.0 Sec 3.0 Sec 3.1.3 Sec 4.0 Sec 4.2 Sec 4.2 Sec I

CR-3	EDA shall provide automatic, semi-automatic, and manual conflict resolution modes	▪ The EDA approach is to take advantage of all three in a hybrid system. ▪ The combination of automatic, semi-automatic, and manual advisory capabilities provides a powerful tool for minimizing controller workload.	Milestone 5.10 Milestone 5.10	Sec 4.2 Sec 4.1
CR-4	EDA shall provide all three resolution modes in a hybrid system	▪ The EDA approach is to take advantage of all three in a hybrid system.	Milestone 5.10	Sec 4.2
CR-5	Automatic resolution shall generate advisories without requiring a dynamic controller input	• The combination of automatic, semi-automatic, and manual advisory capabilities provides a powerful tool for minimizing controller workload.	Milestone 5.10	Sec 4.1
CR-6	Semi-automatic resolution shall generate advisories after the controller dynamically selects the aircraft and advisory type (i.e., DOF)	• The combination of automatic, semi-automatic, and manual advisory capabilities provides a powerful tool for minimizing controller workload.	Milestone 5.10	Sec 4.1
CR-7	Manual resolution shall enable the controller to evaluate the impact of a series of dynamic inputs on a conflict	• The combination of automatic, semi-automatic, and manual advisory capabilities provides a powerful tool for minimizing controller workload.	Milestone 5.10	Sec 4.1
CR-8	EDA shall provide planning, monitoring, and conformance tracking of separation assurance constraints	▪ integrates those advisories with conflict detection and resolution (CD&R) capabilities ▪ it is necessary to integrate DST capabilities for flow-rate conformance and conflict detection and resolution (CD&R) ▪ Integration of flow-rate-conformance advisories with CD&R to reduce controller workload in the planning, monitoring, and conformance of flow-rate restrictions and separation assurance. ▪ The development of DST capabilities for "strategic" flow-rate conformance, and their integration with CD&R capabilities, will minimize ATC interruptions. ▪ Trajectory-oriented solutions are enabled by providing controllers with active flow-rate-	Milestone 5.10 Milestone 5.10 Milestone 5.10 Milestone 5.10 Milestone 5.10 Milestone 5.10	Sec 1.1 Sec 2.0 Sec 3.0 Sec 3.1.3 Sec 4.0 Sec 4.2

		conformance advisories (integrated with CD&R capabilities) and accurate 4D-trajectory predictions. ▪ The piece de resistance of EDA is the integration of CD&R and flow-rate conformance capabilities.		
CR-9	EDA shall provide "active" advisories to resolve separation assurance problems	▪ Trajectory-oriented solutions are enabled by providing controllers with active flow-rate-conformance advisories (integrated with CD&R capabilities) and accurate 4D-trajectory predictions.	Milestone 5.10	Sec 4.0
CR-10	EDA shall support distributed air/ground separation assurance	▪ Fourth, trajectory orientation is a critical enabler for the Free Flight concept, particularly the DAG-TM concepts related to trajectory negotiation or distributed air-ground separation assurance. ▪ Active plans are particularly critical to the configuration management for distributed air-ground (user-ATM) trajectory planning such as trajectory negotiation or airborne free maneuvering	Milestone 5.10 Milestone 5.10	Sec 2.2.2 Sec 4.1
CR-11	EDA shall accept manual controller adjustments to flow rate conformance advisories for conflict resolution	▪ the controller may have selected an automatic cruise/descent-speed advisory for metering, but wishes to manually adjust the descent speed (e.g., trial plan) for conflict resolution. ▪ Controller choice (analogous to the "Trial Planning") ▪ with EDA, the controller may leverage the manual planning capability to "trial plan" a flow-rate conformance solution.	Milestone 5.10 Milestone 5.10 Milestone 5.10	Sec 4.1 Table 2 Sec 4.2
CR-12	CR shall be fully configurable by controllers so that preferences can be set and saved.	▪ Conflict detection/resolution capabilities and the associated interfaces should be fully configurable by the controller so that preferences can be set and saved. Some examples of preferences that controllers requested:	RTO34B CSC DA FD 5/98	Sec 8.2 Sec 3.8.1

		• Detection time horizon for conflicts should be adjustable in the range of 5-20 min • Detection time horizon for flow-rate conformance problems should be adjustable in the range of 5-20 min • Resolution time horizon for conflicts should be adjustable in the range of 5-20 min • Resolution time horizon for flow-rate conformance problems should be adjustable in the range of 5-20 min • Separation minima that will signal an alert should be adjustable in the range of 5-15 nm • Controllers can tailor the operational characteristics of DA.		
CR-13	CR preferences shall include time horizon for resolution (5-20 min)	▪ Conflict detection/resolution capabilities and the associated interfaces should be fully configurable by the controller so that preferences can be set and saved. Some examples of preferences that controllers requested: • Detection time horizon for conflicts should be adjustable in the range of 5-20 min • Detection time horizon for flow-rate conformance problems should be adjustable in the range of 5-20 min • Resolution time horizon for conflicts should be adjustable in the range of 5-20 min • Resolution time horizon for flow-rate conformance problems should be adjustable in the range of 5-20 min • Separation minima that will signal an alert should be adjustable in the range of 5-15 nm	RTO34B	Sec 8.2

CR-14	CR will support metered and non-metered flights	• Build 3 will include flow-conformance advisories, integrated CD/R with resolution advisories for metered and non-metered flights, automation for inter-sector coordination, fast controller inputs and provisional planning, and some limited integration of experimental communication, navigation, surveillance (CNS) capabilities	TO45 SOW	Sec I
CR-15	CR will maximize FMS utilization	• [EDA functions:] efficient descent planning, clearance advisory and monitoring - compatible with airborne FMS-LNAV/VNAV (maximizes FMS utilization)	Steve email 1/14/98	
CR-16	CR will minimize necessary deviations from user preferences	• [EDA functions:] efficient descent planning, clearance advisory and monitoring - supports minimum deviations from user-preferred trajectories when in conflict with others	Steve email 1/14/98	

5.1.4 User Trajectory Negotiation

Number	Requirement Statement	Verbatim Statement	Source Document	Section
TN-1	EDA shall support user trajectory negotiation	▪ Fourth, trajectory orientation is a critical enabler for the Free Flight concept, particularly the DAG-TM concepts related to trajectory negotiation or distributed air-ground separation assurance. ▪ Active plans are particularly critical to the configuration management for distributed air-ground (user-ATM) trajectory planning such as trajectory negotiation or airborne free maneuvering ▪ The purpose of the Active/Provisional approach is support two concepts: 1) Inter/intra-sector coordination of trajectory plans between:	Milestone 5.10 Milestone 5.10 Milestone 5.10	Sec 2.2.2 Sec 4.1 Sec 4.1

		- the R-side and D-side at a sector - two or more sectors within a facility - two or more sectors in two or more facilities 2) Integration of user (FMS & AOC) and ATM DST capabilities (to enable trajectory negotiation).		
TN-2	EDA shall integrate with user (FMS & AOC) DST capabilities to enable trajectory negotiation			
TN-3	EDA shall support the integration of user preferences during user negotiation	• Controller evaluations [of EDA included] … integration of EDA with FMS via datalink to enable the users and controllers to negotiate conflict-free user preferred trajectories	TO45 SOW	Sec I
TN-4	EDA shall communicate with the FMS via datalink	• Controller evaluations [of EDA included] … integration of EDA with FMS via datalink to enable the users and controllers to negotiate conflict-free user preferred trajectories	TO45 SOW	Sec I
TN-5	EDA shall adapt trajectory predictions to individual flight preferences (e.g., speed profile, routing, altitude profile, and time)	• [EDA system capabilities:] supports user-ATM system integration via data exchange (e.g., trajectory negotiation) by adapting trajectory predictions to individual flight preferences (e.g., speed profile, routing, altitude profile, and time), by providing the users with updates of the state of the ATM system (e.g., delay), and by sharing key data with FMS-equipped aircraft to improve the trajectory predictions for both ATM and users (e.g., winds and weight)	Steve email 1/14/98	
TN-6	EDA shall provide users with updates of the states of the ATM system (e.g., delay)	• [EDA system capabilities:] supports user-ATM system integration via data exchange	Steve email 1/14/98	

		(e.g., trajectory negotiation) by adapting trajectory predictions to individual flight preferences (e.g., speed profile, routing, altitude profile, and time), by providing the users with updates of the state of the ATM system (e.g., delay), and by sharing key data with FMS-equipped aircraft to improve the trajectory predictions for both ATM and users (e.g., winds and weight)		
TN-7	EDA shall share key data with FMS-equipped aircraft to improve the trajectory predictions of EDA and FMS (e.g., wind and weight)	• [EDA system capabilities:] supports user-ATM system integration via data exchange (e.g., trajectory negotiation) by adapting trajectory predictions to individual flight preferences (e.g., speed profile, routing, altitude profile, and time), by providing the users with updates of the state of the ATM system (e.g., delay), and by sharing key data with FMS-equipped aircraft to improve the trajectory predictions for both ATM and users (e.g., winds and weight)	Steve email 1/14/98	

5.1.5 Trajectory-Oriented Planning and Conformance Monitoring

Number	Requirement Statement	Verbatim Statement	Source Document	Section
TP-1	EDA shall support the development of active and provisional plans	▪ Active plans are particularly critical to the configuration management for distributed air-ground (user-ATM) trajectory planning such as trajectory negotiation or airborne free maneuvering ▪ The purpose of the Active/Provisional approach is support two concepts: 1) Inter/intra-sector coordination of trajectory plans between:	Milestone 5.10 Milestone 5.10 TO45 SOW TO45 SOW	Sec 4.1 Sec 4.1 Sec I Sec I

		- the R-side and D-side at a sector - two or more sectors within a facility - two or more sectors in two or more facilities 2) Integration of user (FMS & AOC) and ATM DST capabilities (to enable trajectory negotiation). ▪ A fundamental challenge for the ATM aspect of CE-5/6 is to enable controllers to manage traffic with a trajectory orientation ▪ Build 3 will include flow-conformance advisories, integrated CD/R with resolution advisories for metered and non-metered flights, automation for inter-sector coordination, fast controller inputs and provisional planning, and some limited integration of experimental communication, navigation, surveillance (CNS) capabilities		
TP-2	EDA shall support distributed air-ground (user-ATM) trajectory planning	▪ Fourth, trajectory orientation is a critical enabler for the Free Flight concept, particularly the DAG-TM concepts related to trajectory negotiation or distributed air-ground separation assurance. ▪ Active plans are particularly critical to the configuration management for distributed air-ground (user-ATM) trajectory planning such as trajectory negotiation or airborne free maneuvering ▪ Today's procedures are predominantly oriented towards airspace whereas user preferences are predominantly oriented towards trajectories. This paradox is a primary	Milestone 5.10 Milestone 5.10 Milestone 5.10 Milestone 5.10 Milestone 5.10 TO45 SOW	Sec 2.2.2 Sec 4.1 Sec 2.0 Sec 2.2.2 Sec 4.0 Sec I

		obstacle that must be overcome to realize the en route aspects of DAG-TM. ▪ The solution to these problems is to develop controller roles, responsibilities, procedures, and supporting automation that facilitate "trajectory-oriented" planning while maintaining (or enhancing) the level of safety. ▪ The EDA concept is based on the development of procedures, DST capabilities, and supporting technologies, to facilitate trajectory-orientated operations resulting in a more efficient and productive en route ATC service. ▪ A fundamental challenge for the ATM aspect of CE-5/6 is to enable controllers to manage traffic with a trajectory orientation		
TP-3	EDA shall support airborne free maneuvering	▪ Fourth, trajectory orientation is a critical enabler for the Free Flight concept, particularly the DAG-TM concepts related to trajectory negotiation or distributed air-ground separation assurance. ▪ Active plans are particularly critical to the configuration management for distributed air-ground (user-ATM) trajectory planning such as trajectory negotiation or airborne free maneuvering ▪ A fundamental challenge for the ATM aspect of CE-5/6 is to enable controllers to manage traffic with a trajectory orientation	Milestone 5.10 Milestone 5.10 TO45 SOW	Sec 2.2.2 Sec 4.1 Sec I
TP-4	EDA planning shall support intra-sector (R- and D-side) coordination of trajectory plans	▪ The purpose of the Active/Provisional approach is support two concepts: 1) Inter/intra-sector coordination of trajectory plans between: - the R-side and D-side at a sector	Milestone 5.10 TO45 SOW	Sec 4.1 Sec I

		- two or more sectors within a facility - two or more sectors in two or more facilities 2) Integration of user (FMS & AOC) and ATM DST capabilities (to enable trajectory negotiation). ▪ A fundamental challenge for the ATM aspect of CE-5/6 is to enable controllers to manage traffic with a trajectory orientation		
TP-5	EDA planning shall support inter-sector (two or more sectors within a facility) of trajectory plans	▪ The purpose of the Active/Provisional approach is support two concepts: 1) Inter/intra-sector coordination of trajectory plans between: - the R-side and D-side at a sector - two or more sectors within a facility - two or more sectors in two or more facilities 2) Integration of user (FMS & AOC) and ATM DST capabilities (to enable trajectory negotiation). ▪ A fundamental challenge for the ATM aspect of CE-5/6 is to enable controllers to manage traffic with a trajectory orientation ▪ Build 3 will include flow-conformance advisories, integrated CD/R with resolution advisories for metered and non-metered flights, automation for inter-sector coordination, fast controller inputs and provisional planning, and some limited integration of experimental communication,	Milestone 5.10 TO45 SOW TO45 SOW	Sec 4.1 Sec I Sec I

		navigation, surveillance (CNS) capabilities		
TP-6	EDA planning shall support inter-facility (two or more sectors in two or more facilities) of trajectory plans	▪ The purpose of the Active/Provisional approach is support two concepts: 1) Inter/intra-sector coordination of trajectory plans between: - the R-side and D-side at a sector - two or more sectors within a facility - two or more sectors in two or more facilities 2) Integration of user (FMS & AOC) and ATM DST capabilities (to enable trajectory negotiation). ▪ A fundamental challenge for the ATM aspect of CE-5/6 is to enable controllers to manage traffic with a trajectory orientation	Milestone 5.10 TO45 SOW	Sec 4.1 Sec I
TP-7	EDA shall support controller input trial plans	▪ Controller choice (analogous to the “Trial Planning”) ▪ with EDA, the controller may leverage the manual planning capability to “trial plan” a flow-rate conformance solution. ▪ A fundamental challenge for the ATM aspect of CE-5/6 is to enable controllers to manage traffic with a trajectory orientation	Milestone 5.10 Milestone 5.10 TO45 SOW	Table 2 Sec 4.2 Sec I
TP-8	EDA trial planning shall integrate with flow conformance capabilities to provide flow conformance feedback during trial planning	▪ the controller may have selected an automatic cruise/descent-speed advisory for metering, but wishes to manually adjust the descent speed (e.g., trial plan) for conflict resolution. ▪ Controller choice (analogous to the “Trial Planning”) ▪ with EDA, the controller may leverage the manual planning capability to “trial plan” a flow-rate conformance solution.	Milestone 5.10 Milestone 5.10 Milestone 5.10 TO45 SOW	Sec 4.1 Table 2 Sec 4.2 Sec I

		▪ A fundamental challenge for the ATM aspect of CE-5/6 is to enable controllers to manage traffic with a trajectory orientation		
TP-9	EDA planning shall provide direct and continuous feedback on each flight's conformance with the active clearance (controller intent)	▪ A critical DST capability is the feedback on the ramifications of controller actions and plans. ▪ This set of functions provides the controller with direct and continuous feedback on each flight's conformance with the active clearance (controller intent). ▪ A fundamental challenge for the ATM aspect of CE-5/6 is to enable controllers to manage traffic with a trajectory orientation	Milestone 5.10 Milestone 5.10 TO45 SOW	Sec 2.1 Sec 4.2 Sec I
TP-10	EDA shall accept manual controller inputs to update the active plan	▪ These functions serve to infer intent from the information available to the EDA including radar track data, flight plan amendments, EDA advisory modes, and controller inputs (e.g., manual updates to the active plan). This function combines all the available data to determine the intended route/altitude/speed profile in support of trajectory predictions. ▪ A fundamental challenge for the ATM aspect of CE-5/6 is to enable controllers to manage traffic with a trajectory orientation	Milestone 5.10 TO45 SOW	Sec 4.2 Sec I
TP-11	EDA shall support a common situational awareness across sectors to ensure complementary plans and actions	• The technology must support a common situational awareness across sectors to ensure that plans and actions are complementary. • A fundamental challenge for the ATM aspect of CE-5/6 is to enable controllers to manage traffic with a trajectory orientation	RTO34B TO45 SOW	Sec 5.4.3 Sec I
TP-12	EDA shall support controller input of all commonly used actions to change the nominal flight plan, including: direct-to route modifications; path-stretch/S turns; air hold; release air hold; change in airway; ignore crossing restriction; modify crossing restriction; immediate	▪ All the commonly used actions by controllers and pilots that result in changes to the nominal flight plan would be entered into the system through easily accessed interface entry options. Examples of intent choices (e.g., via a pull-down menu) are listed below:	RTO34B TO45 SOW	Sec 8.1 Sec I

	climb/descent; climb/descend at a fix; immediate increase/reduce speed	• "Direct to" – allows aircraft to fly from current position to a downstream fix, airport, etc. • Path-stretch/S-turns – allows aircraft to fly prescribed maneuver for prescribed time. • Air hold – allows aircraft to be place into a holding pattern at the current location. This would effectively "pause" the trajectory synthesis predictions until the aircraft was released from the hold. An alert of a potential conflict should be signaled for any other aircraft that is predicted to pass near the oval-shaped airspace of the holding aircraft • Release air hold – allows aircraft to be released from hold and resume original flight plan • Change in airway – allows aircraft to switch from current airway to another airway at the next shared intersection • Ignore crossing restriction – allows aircraft to maintain current speed/altitude despite an active crossing restriction requirement that is in effect. • Modify crossing restriction – allows aircraft to meet a modified crossing restriction requirement (e.g., meets the nominal altitude, but at a faster speed) • Climb/descend immediately – allows aircraft to climb/descend to specified altitude • Climb/descend at specified fix – allows aircraft to climb/descend to specified altitude at specified fix • Increase/reduce speed immediately – allows aircraft to immediately		

		increase/reduce speed as specified ▪ A fundamental challenge for the ATM aspect of CE-5/6 is to enable controllers to manage traffic with a trajectory orientation		
TP-13	EDA shall calculate each clearance's (route, altitude, speed) conformance and indicate non-conformant states	▪ Each flight's state of clearance conformance (for route, altitude, and speed) is explicitly indicated on the graphical user interface with specific cues to indicate non-conformance states. ▪ A fundamental challenge for the ATM aspect of CE-5/6 is to enable controllers to manage traffic with a trajectory orientation	Milestone 5.10 TO45 SOW	Sec 4.0 Sec I
TP-14	EDA shall support the controller situation awareness of the active plan, advisory mode and controller constraints/overrides, pending decision points and required actions, and conformance to active plan	▪ Maintain controller situational awareness of: i) the "active" trajectory plan ii) the advisory mode and controller constraints/over-rides iii) pending decision points and required actions (e.g., clearances) iv) aircraft conformance with the active plan ▪ A fundamental challenge for the ATM aspect of CE-5/6 is to enable controllers to manage traffic with a trajectory orientation	Milestone 5.10 TO45 SOW	Sec 5.2 Sec I
TP-15	EDA trajectory-oriented planning shall be configurable by controllers	• Controllers can tailor the operational characteristics of DA. • A fundamental challenge for the ATM aspect of CE-5/6 is to enable controllers to manage traffic with a trajectory orientation	CSC DA FD 5/98 TO45 SOW	Sec 3.8.1 Sec I
TP-16	EDA shall support the Upstream Sector Team concept for inter-sector coordination	• A fundamental challenge for the ATM aspect of CE-5/6 is to enable controllers to manage traffic with a trajectory orientation • An analysis … necessary to support the	TO45 SOW TO45 SOW	Sec I Sec II

		controller roles and responsibilities associated with the Upstream Sector Team concept defined in TO34B		
TP-17	EDA shall take downstream conflicts, merges and flow constraints into account during planning	• A fundamental challenge for the ATM aspect of CE-5/6 is to enable controllers to manage traffic with a trajectory orientation • Trajectory oriented planning accounts for downstream constraints: conflicts, merges, MIT/metering	TO45 SOW Steve presentation 10/11/98	Sec I
TP-18	EDA shall develop controller plans based on accurate intent	• A fundamental challenge for the ATM aspect of CE-5/6 is to enable controllers to manage traffic with a trajectory orientation • [Inter-sector] Coordination should build on "good" trajectory plans (accurate intent)	TO45 SOW Steve email 1/14/98	Sec I
TP-19	EDA shall use "active" inputs (speed, altitude, routing) to improve controller intent in trajectory predictions	• A fundamental challenge for the ATM aspect of CE-5/6 is to enable controllers to manage traffic with a trajectory orientation • ["active" inputs (speed, altitude, routing) are] one way (complementary to heuristics) to improve intent	TO45 SOW Steve email 1/14/98	Sec I
TP-20	EDA shall create R-side functionality with supporting D-side functionality	• A fundamental challenge for the ATM aspect of CE-5/6 is to enable controllers to manage traffic with a trajectory orientation • Objective is to develop an R-side controller tool with supporting D-side functionality	TO45 SOW Steve email 1/1/4/98	Sec I
TP-21	EDA shall provide maneuver feedback that allows a controller to observe the progressive effect of a clearance issued but not input into the system	• A fundamental challenge for the ATM aspect of CE-5/6 is to enable controllers to manage traffic with a trajectory orientation • [EDA system capabilities:] maneuver	TO45 SOW Steve email 1/14/98	Sec I

		feedback capabilities that allow a controller to issue a clearance and observe the progressive effect of the clearance when not input to the system (used for dynamic maneuvers when a fully planned trajectory is not desired)		
TP-22	EDA shall support inter-sector coordination through the electronic exchange of provisional plans	• A fundamental challenge for the ATM aspect of CE-5/6 is to enable controllers to manage traffic with a trajectory orientation • [EDA system capabilities:] supports inter-sector/facility coordination (conflict resolutions and traffic management) through the exchange of electronic provisional plans	TO45 SOW Steve email 1/14/98	Sec I
TP-23	EDA shall support non-verbal inter-sector coordination through coordinated information display	• A fundamental challenge for the ATM aspect of CE-5/6 is to enable controllers to manage traffic with a trajectory orientation • [EDA system capabilities:] supports non-verbal inter-sector coordination through coordinated information display	TO45 SOW Steve email 1/14/98	Sec I
TP-24	EDA shall provide integrated non-standard route planning, clearance advisory and monitoring (including free vectoring)	• A fundamental challenge for the ATM aspect of CE-5/6 is to enable controllers to manage traffic with a trajectory orientation • [EDA functions:] integrated non-standard route planning, clearance advisory and monitoring (including free vectoring)	TO45 SOW Steve email 1/14/98	Sec I

5.1.6 Intent Inferencing

Number	Requirement Statement	Verbatim Statement	Source Document	Section
II-1	EDA shall infer intent from the information available to EDA including radar track, flight plan	▪ These functions serve to infer intent from the information available to the EDA including	Milestone 5.10	Sec 4.2

	amendments, EDA advisory modes, and controller inputs	radar track data, flight plan amendments, EDA advisory modes, and controller inputs (e.g., manual updates to the active plan). This function combines all the available data to determine the intended route/altitude/speed profile in support of trajectory predictions.		
II-2	EDA shall determine the intended route/altitude/speed profile from the inferred intent in support of trajectory predictions	▪ These functions serve to infer intent from the information available to the EDA including radar track data, flight plan amendments, EDA advisory modes, and controller inputs (e.g., manual updates to the active plan). This function combines all the available data to determine the intended route/altitude/speed profile in support of trajectory predictions.	Milestone 5.10	Sec 4.2
II-3	EDA shall consider controller intent, pilot-discretion intent, and pilot-deviation intent	▪ en route DST capability is needed to improve the efficiency with which en route controllers conform to flow-rate restrictions ▪ A tool can enable controllers to strategically plan their flow-rate conformance actions resulting in a reduction in workload, flight deviations, and fuel consumption.	Milestone 5.10 Milestone 5.10	Sec 2.0 Sec 2.0
II-4	EDA shall use heuristics and controller inputs to identify missing intent.	▪ This void [due to lack of intent] can be filled by a combination of better heuristics and controller inputs	Steve email 1/14/98	
II-5	EDA shall use intent inferencing prior to developing controller plans	▪ [Inter-sector] Coordination should build on "good" trajectory plans (accurate intent)	Steve email 1/14/98	

6.0

6.1 List of Acronyms:

ACID	Aircraft Identification (ID)
ARTCC	Air Route Traffic Control Center
CAST	Center Automation and Sequencing Tool
CTAS	Center/TRACON Automation System
DOF	Degree of Freedom
DSR	Display System Replacement
EDA	Enroute Descent Advisor
ETA	Estimated Time of Arrival
FAB	Fast Action Button
FDB	Flight Data Block
FMS	Flight Management System
GUI	Graphical User Interface
ID	Identification
RDT&E	Research, Development, Test, and Evaluation
RGL	Remote Graphics Language
STA	Scheduled Time of Arrival
TBD	To Be Determined
UTC	Universal Coordinated Time
VSCS	Voice System Control

Annex A: Metered Aircraft Resolution Algorithm from Reference [4]